- *Monitoring and maintenance*—these activities would include inspections and sampling conducted in accordance with the site's Long-Term Surveillance and Maintenance Plan, which would be approved by NRC.

As applicable, the impacts from these activities are summarized for each resource. Impacts at the 10 borrow areas analyzed are addressed in Section 4.5. The No Action alternative is discussed in Section 4.6.

Consistent with DOE and Council on Environmental Quality NEPA guidance, the analysis of impacts in this chapter focuses on those areas in which impacts may occur from any action proposed by the alternatives assessed in this EIS. For this reason, the level of detail and analysis varies among the resource areas according to the duration and degree of the expected impact.

4.1 On-Site Disposal (Moab Site)

This section discusses the short-term and long-term impacts associated with the on-site disposal alternative. The impacts are based on the proposed actions described in Section 2.1 and the affected environment described in Section 3.1. This alternative would result in impacts at the Moab site, vicinity properties, and borrow areas, and transportation impacts associated with commuting workers and the transport of vicinity property material and borrow material. The combined impacts that may result from these activities are summarized for each assessment area (e.g., Geology and Soils) at the end of each subsection.

4.1.1 Geology and Soils

4.1.1.1 Construction and Operations Impacts at the Moab Site

Geology

Proposed surface or ground water remediation at the Moab site would not be affected by seismic factors. The Moab site is located in an area where evidence indicates that significant earthquakes are rare. The Moab Fault lies deep beneath the site, but it does not pose a significant earthquake or surface-rupture threat to the tailings pile and is not a capable fault under NRC siting criteria. The site lies within Uniform Building Code 1, indicating the lowest potential for earthquake damage.

Two geologic processes, subsidence (basin settling) and incision (cutting into bedrock by the Colorado River), would affect the tailings pile very slowly over very long periods of time. These processes are discussed in Section 3.1.1.4. Incision and subsidence rates indicate that the impact to a disposal cell at the Moab site over the 1,000-year regulatory design period would be to lower the elevation of the cell by approximately 1.4 ft in relation to the Colorado River. This would place the 100-year floodplain of the Colorado River about 1.4 ft higher on the east toe of the cell, creating a higher probability for flooding over time. This potential impact would be very long term, and the potential hazard would be reduced by the proposed buried riprap diversion wall (see Figure 2−3). The proposed ground water remediation would not be affected by these long-term geologic processes. Subsidence would result in the tailings coming into permanent contact with the ground water in approximately 7,000 to 10,000 years.

Several geologic resources exist beneath the disposal cell, including sand and gravel, saline minerals, and brine. The sand and gravel resource would be adversely affected by the proposed on-site disposal alternative because it provides a foundation for the disposal cell and would have to remain undisturbed in perpetuity; therefore, this resource would be unavailable for commercial exploitation. Saline minerals and brine resources would not be affected because they could be physically accessed and recovered by slant drilling from areas adjacent to the site. However, past mill operations have likely introduced sufficient quantities of contaminants to these resources to prohibit future use under any alternative.

Soils

The major impact on soils at the Moab site under the on-site disposal alternative would be the excavation and relocation onto the tailings pile of approximately 234,000 tons (173,000 yd^3) of off-pile contaminated site soil and the backfilling (replacement) of these soils with approximately 320,000 yd^3 of clean reclamation borrow soil to a depth of approximately 6 inches. These would be short-term impacts that would result in some potential for soil erosion due to the site soil characteristics discussed in Section 3.1.2. The potential for erosion would continue until the cover was installed, the reclamation soil emplaced, and vegetation established. The potential for erosion would be reduced through implementation of the *Fugitive Dust Plan for the Moab, Utah, UMTRA Project Site* (DOE 2002a) and Utah Pollutant Discharge Elimination System storm water discharge requirements. Soil subsidence, a form of subsidence associated with surface flow and erosion processes, could occur at the site through the development of soil pipes, or voids in the soil. However, no soil pipes have been discovered to date, and the engineered cell would control surface flow to prevent the development of soil pipes and subsequent soil subsidence adjacent to the cell. Ground water remediation would not affect soils. Reclamation and revegetation, the final proposed construction phase (Section 2.1.1.4), would leave the soils on and surrounding the tailings impoundment less vulnerable to erosion than they are today.

4.1.1.2 Impacts from Characterization and Remediation of Vicinity Properties

Soil impacts at the vicinity properties would be qualitatively similar to those for the Moab site, but on a much smaller scale. The average area of disturbance at a vicinity property is expected to be 2,500 ft^2, less than 6 percent of an acre, and the total area of soil disturbance to all vicinity properties is expected to be approximately 6 acres. As necessary and appropriate, erosion control measures would be implemented as described for the Moab site. Remediation of vicinity properties would not be affected by geologic features or processes. It is highly unlikely that any geologic resources exist at any vicinity properties in quantities or locations that would justify commercial interest.

4.1.1.3 Impacts from All Sources

The loss of potential commercial availability of sand and gravel resources underlying the tailings pile could be a negative long-term impact to geologic resources. However, it is likely that these resources are contaminated from previous mill operations and are therefore unusable under any alternative. There would be a negative long-term impact on the disposal cell due to a very slow subsidence of the cell (1.4 ft over 1,000 years) into the 100-year floodplain of the Colorado River on the east toe of the cell, but this impact would not result in collapse of the pile. Negative, short-term impacts on soils would result from excavating contaminated soils, conducting construction activities, depositing contaminated materials in the tailings pile, recontouring, and capping the tailings pile. These activities would affect approximately 439 acres of the Moab site and 6 acres of vicinity properties. There would be no geologic or soils-related impacts associated with transportation, ground water remediation, or monitoring and maintenance activities under the on-site disposal alternative.

4.1.2 Air Quality

4.1.2.1 Construction and Operations Impacts at the Moab Site

During surface and ground water remediation (described in Sections 2.1.1 and 2.3.2), heavy-duty diesel equipment such as excavators, scrapers, and dozers would emit pollutants. Fugitive dust emissions would also occur. However, emission of fugitive dust would be minimized by using control measures, such as applying water or chemicals and covering truck beds. As shown in Table 4–1, the concentrations of criteria pollutants from the Moab site emissions are below the primary and secondary NAAQS in 40 CFR 50. The estimated concentrations of criteria air pollutants from emissions shown in Table 4–1 were derived by applying tailpipe emission factors provided in *Compilation of Air Pollutant Emission Factors* (EPA 2000) to the estimated construction fleet composition and duration of construction operations. With respect to PSD, and as noted in Section 3.1.4, the Moab site is in a Class II area but shares a common boundary with Arches National Park, a Class I area where maximum allowable increases in PM_{10} are limited to 4 $\mu g/m^3$ (annual arithmetic mean) and 8 $\mu g/m^3$ (24-hour maximum). However, Utah PSD regulations provide that concentrations of PM_{10} attributable to the increases in emissions from construction or other temporary emission-related activities shall be excluded in determining compliance with the maximum allowable increase (UAC 2000).

Table 4–1. Criteria Pollutant Concentrations from Emissions at the Moab Site

Pollutant	Averaging Period	Standard ($\mu g/m^3$)	Concentration from Emissions ($\mu g/m^3$)
Carbon monoxide	1-hour	40,000	31
	8-hour	10,000	22
Nitrogen dioxide	Annual	100	7.0
Sulfur dioxide	Annual	80	0.71
	24-hour	365	3.6
	3-hour	1,300	8.0
PM_{10}[a]	Annual	50	3.0
	24-hour	150	15

[a]PM_{10} includes fugitive dust emissions from construction activities.
$\mu g/m^3$ = micrograms per cubic meter.

In addition to the short-term criteria air pollutant emissions shown in Table 4–1, some long-term air emissions would be associated with ground water extraction and treatment activities. Emissions from ground water extraction would be expected to be minor because the system would probably use electric pumps. Emissions from treatment activities would depend on the treatment technology used. As noted in Section 2.3.2, operation of an evaporation pond, particularly spray evaporation, or ammonia-stripping treatment technology would probably be the alternatives with the highest potential for air emissions. Potential impacts from these emissions are discussed in Section 4.1.15, “Human Health,” subsection 4.1.15.1, “Construction and Operations Impacts at the Moab Site.”

4.1.2.2 Impacts from Characterization and Remediation of Vicinity Properties

During the remediation of vicinity properties, heavy-duty diesel trucks used to haul materials, automobiles used by workers, and backhoes or scrapers used to excavate, load, and unload materials would emit pollutants. Fugitive dust emissions would also occur, but they would be small because of the small acreage disturbed at each vicinity property (estimated to average 0.06 acre) and the relatively high moisture content of the material (DOE 1985). In addition, emission of fugitive dust at vicinity properties would be minimized by using control measures, such as applying water or chemicals and covering open truck beds.

During remediation of a typical vicinity property, an estimated 12.9 pounds of hydrocarbons, 23.6 pounds of nitrogen oxides, 0.7 pound of sulfur oxides, 157.6 pounds of carbon monoxide, and 0.5 pound of total suspended particulates would be emitted (DOE 1985). For remediation of 98 vicinity properties, a total of about 1,300 pounds of hydrocarbons, 2,300 pounds of nitrogen oxides, 70 pounds of sulfur oxides, 15,000 pounds of carbon monoxide, and 50 pounds of total suspended particulates would be emitted from vehicles. These emissions would be distributed geographically and temporally and would not cause any permanent air quality impacts (DOE 1985).

4.1.2.3 Construction and Operations Impacts Related to Transportation

The air quality impacts of transportation under the on-site disposal alternative are discussed in Section 4.1.15, "Human Health," subsection 4.1.15.3.

4.1.2.4 Monitoring and Maintenance Impacts

During monitoring and maintenance activities, there would be minimal use of heavy equipment on the Moab site. Therefore, concentrations of criteria pollutants would be similar to the background concentrations shown in Table 3−5, "Air Quality in the Moab Region."

4.1.2.5 Impacts from All Sources

Emissions of criteria air pollutants, including carbon monoxide, nitrogen dioxide, sulfur dioxide, and PM_{10}, would occur at the Moab site and at vicinity properties because of the operation of heavy construction equipment and ground water remediation equipment. No criteria air pollutant emission concentrations at the Moab site, where concentrations are expected to be highest, would exceed NAAQS.

4.1.3 Ground Water

This section describes the short-term and long-term impacts to ground water that would result from on-site disposal of contaminated site and vicinity property materials. Ground water impacts would directly affect surface water. Impacts are assessed assuming that the final disposal cell would be in the same location as the existing tailings pile. The impacts analysis is based on the proposed action and alternatives described in Sections 2.1 and 2.3 and the affected environment as described in Section 3.1.6. No impacts to ground water at the site would result from remediation of vicinity properties, transportation activities, or monitoring and maintenance. Therefore, no further discussion for these activities is included in this section.

According to the most recent site conceptual model, three discrete mechanisms for contaminant transport are affecting the site ground water system: (1) downward seepage of contaminated fluids from the tailings pile to the ground water, (2) upward flux of contaminants from the brine interface to the freshwater layer, and (3) lateral movement of the legacy plume in the upper alluvial aquifer. All three are contributing ammonia to the Colorado River. Ground water potentially migrating beneath the Colorado River from the site is not anticipated to affect surface waters or aquatic communities on the east side of the river, in the vicinity of the Matheson Wetlands Preserve.

The naturally high salt content in the ground water prevents it from being a potential source of drinking water. Contaminated ground water would not be made available to the public and therefore would not pose a risk to public health. The impact analysis in this section addresses contaminants in ground water that influence surface water quality and subsequently aquatic receptors. Previous studies, recent DOE evaluations (DOE 2003a), and Chapter 3.0 indicate that ammonia is the primary contaminant of concern in ground water and could pose a risk to aquatic receptors in surface water. Active remediation of ground water would reduce the mass of ammonia discharging to the Colorado River and would prevent long-term adverse impacts to surface water and aquatic receptors. Active remediation would also ensure long-term protection of surface water and ecological receptors from risk that may be caused by other contaminants.

4.1.3.1 Construction and Operations Impacts at the Moab Site

For purposes of this EIS, short-term impacts to ground water would include the period from completion of the RAP until concentrations in the surface water were protective of aquatic species, as described in Section 2.3. Therefore, short-term impacts would include those that would occur to ground water during surface remediation and during preparation of the site for active ground water remediation. Long-term impacts to ground water would be those that would occur during and after active remediation.

Although short-term impacts would not adversely affect human health, ground water impacts are discussed to provide an explanation of potential effects on surface water. In the short term, the potential exists for ammonia concentrations to increase slightly in the river as a result of tamarisk removal during surface remediation. If tamarisk were reestablished, phytoremediation would likely augment ground water and contaminant mass removal in ground water through root uptake. This, combined with active ground water remediation, would likely decrease ammonia concentrations affecting surface water. Tailings seepage and ammonia flux are all expected to decrease gradually both in the short and long term. Installation of extraction wells and trenches necessary for active remediation would not adversely affect ground water. Applications of clean water (discussed in Section 2.3.2.4) would not adversely affect ground water quality, as such applications are designed to enhance the quality of surface water.

In the long term, capping the tailings pile would reduce concentrations of ground water contaminants, including ammonia, to levels well below those currently existing, because decreased infiltration rates of precipitation through the tailings would reduce tailings pore fluid seepage. The seepage rate of tailings pore fluids would decline from the current rate of 20 gpm until consolidation of the tailings was complete and the steady-state condition of 0.8 gpm was reached in approximately 130 years. Ammonia flux from the brine and the legacy plume would decrease gradually through the action of natural processes (e.g., adsorption, geochemical degradation, dispersion) to background concentrations, as fresh ground water entered the site from recharge areas in the vicinity of Moab Wash and flowed beneath the tailings pile toward the Colorado River and as the contaminant mass in the brine was depleted.

Assumptions for tailings drainage and ammonia concentrations are presented in Table 4–2.

Table 4–2. Assumptions for Liquid Drainage and Ammonia Concentrations From the Tailings Pile for the On-Site Disposal Alternative

Parameter	Value
Infiltration rate	1×10^{-7} cm/s before construction and 1×10^{-8} cm/s after construction
Gravity drainage	Rate would decay from 8 gpm at present to 0.8 gpm at 130 years
Transient drainage	Rate would decay from 12 gpm at present to 0 gpm at 20 years
Initial ammonia concentration seepage from base of tailings pile	1,100 mg/L
Breakthrough ammonia concentration from upper salt layer	18,000 mg/L
Arrival time	1,100 years
Final concentration	1,100 mg/L
Exit time	1,540 years

cm/s = centimeters per second; gpm = gallons per minute; mg/L = milligrams per liter

Limited data suggest that there may be significantly higher ammonia concentrations in the upper 10 ft of tailings related to a 3- to 6-inch salt layer (DOE 2003a). In the future, as water infiltrates the upper portion of the tailings, it may dissolve the salt deposits, and pore fluid concentrations seeping from the base of the tailings could have up to 18,000 mg/L ammonia. These high concentrations would persist as long as salt deposits remain in the tailings. If the salt deposits become depleted by dissolution from infiltrating water, pore fluid concentrations would decrease. It is estimated that it would take approximately 1,100 years (longer than the disposal cell design life) for the relatively high ammonia concentrations to reach the ground water, and dissolution would continue for approximately 440 years until the salt layer was depleted. It is assumed that after the salt layer was depleted (in approximately 1,540 years), ammonia concentrations in the pore fluids would return to 1,100 mg/L (DOE 2003a).

Available information is insufficient to reliably estimate the inventory of soluble mineral salts in the tailings, estimate the time for the salts to be completely depleted, or predict the future geochemical transformations that may occur. However, mineral depletion would trigger rapid decreases in pore water dissolved solids and ammonia concentrations. Because of the slow flow of water through the tailings, it is unlikely that mineral depletion would occur in any reasonable time period. In addition, the chemistry of the pore fluid would likely change as it percolated down through the tailings. Pore water pH would increase, and some minerals would form from reaction with minerals such as calcium carbonate. As acidic, high-concentration ammonia pore water moved down through high-pH, carbonate-bearing tailings, chemical precipitation would occur, and concentrations of some constituents would decrease. Thus, the ammonia concentration estimated at 18,000 mg/L (ammonia-N) could be significantly lower.

Ground water flow and transport modeling described in the SOWP (DOE 2003a) was performed to evaluate the impact of the on-site disposal alternative to the ground water system near the Colorado River from the three contaminant transport mechanisms (brine flux, legacy plume, and tailings seepage) over a period of 200 years. The modeling results, presented in Figure 4–1, indicate that most of the ammonia flux from the brine layer and the legacy plume in the alluvial aquifer would naturally flush to the river in approximately 80 years. At the end of the 80-year period, seepage of 1,100 mg/L ammonia from the base of the tailings pile would continue to decline until it reached a steady-state rate of 0.8 gpm; ground water concentrations near the river would decline below 0.7 mg/L ammonia after 200 years but remain above background. Predicted concentrations plotted in Figure 4–1 represent the maximum ammonia-N concentrations for a series of observations located along a transect parallel to the Colorado River downgradient from the toe of the tailings pile along a flow path near the center of the plume.

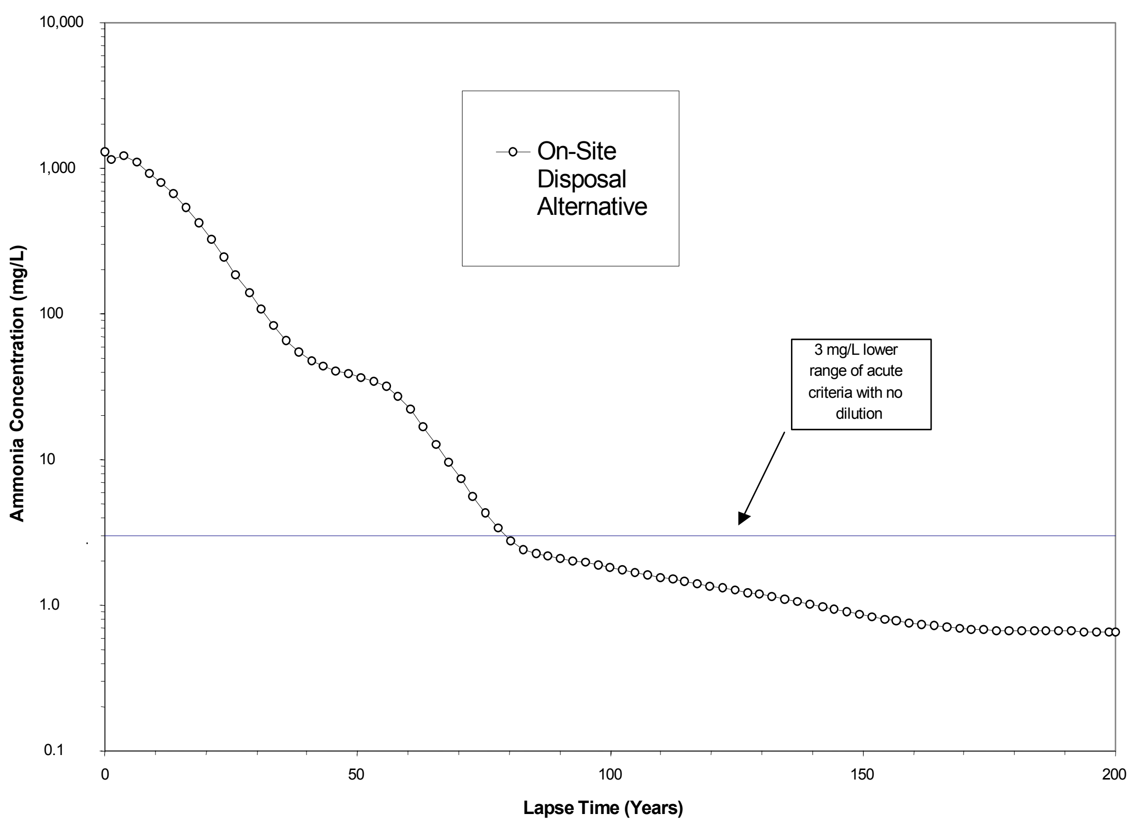

Figure 4–1. Predicted Maximum Ammonia Concentrations in Ground Water Adjacent to the Colorado River for the On-Site Disposal Alternative

The target goal of 3 mg/L for ammonia in ground water, as discussed in Chapter 2.0, provides reasonable assurance of meeting the surface water remediation objective to provide protection of aquatic species. Modeling results indicate the ammonia concentrations in ground water near the bank of the Colorado River would be expected to decline from the current 500 to 1,000 mg/L to a maximum of approximately 3 mg/L in 80 years, and less than 0.7 mg/L at steady state in 200 years. Predicted concentrations in the ground water at 80 and 200 years in the future are summarized in Table 4–3. Predicted concentrations after 80 years and 200 years are illustrated in Figure 4–2 and Figure 4–3, respectively. As evident from the data presented in Table 4–3 and Figure 4–2, the on-site disposal alternative would meet the 3-mg/L target goal in ground water adjacent to the backwater habitat area.

Table 4–3. Predicted Ammonia Concentrations in the Ground Water Adjacent to the Colorado River Resulting From the On-Site Disposal Alternative

Maximum Ammonia Concentration (mg/L) in Ground Water Adjacent to Backwater Habitat Area	Time (years) to Reach Concentrations[a]	Achieve 3.0 mg/L Target Goal With No Dilution
3.0	80	Yes
0.7	200 (steady-state)	Yes

[a]Time to reach predicted concentration rounded to nearest 5-year increment.

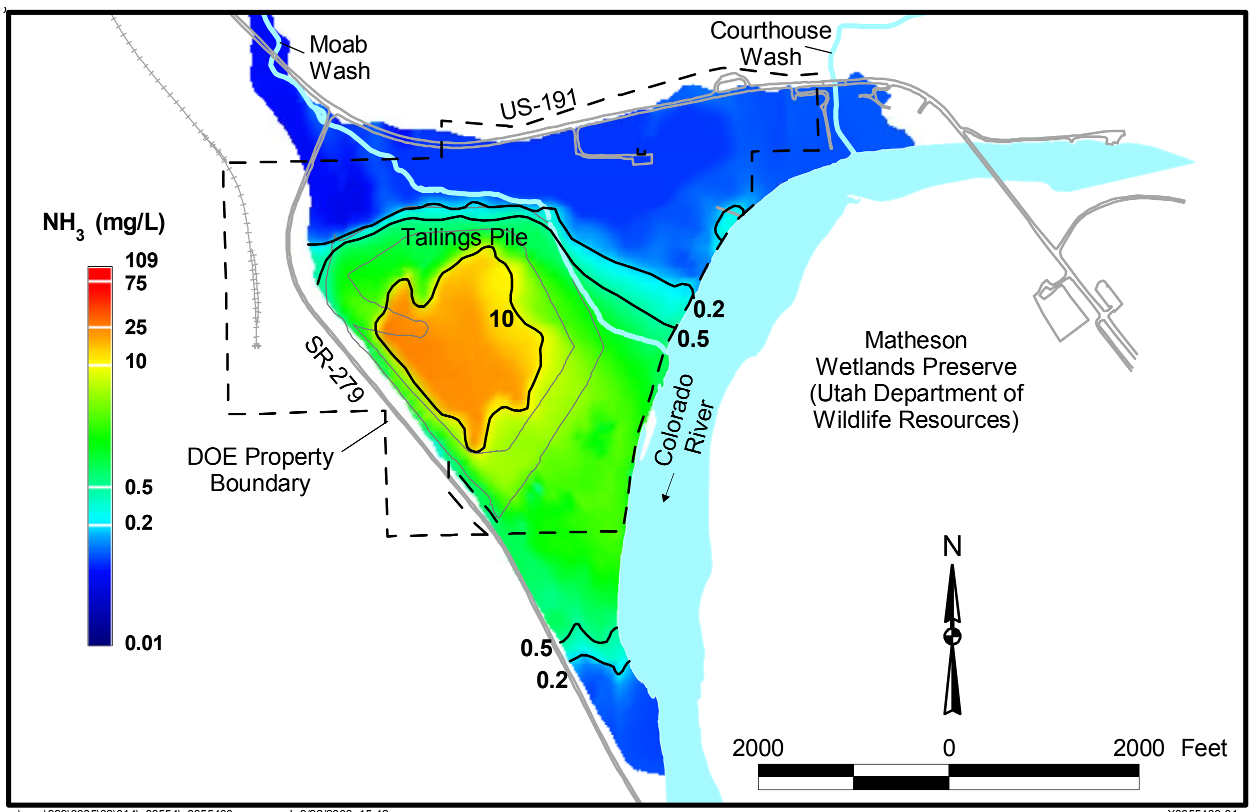

Figure 4–2. Predicted Ammonia Concentrations in the Ground Water After 80 Years for the On-Site Disposal Alternative

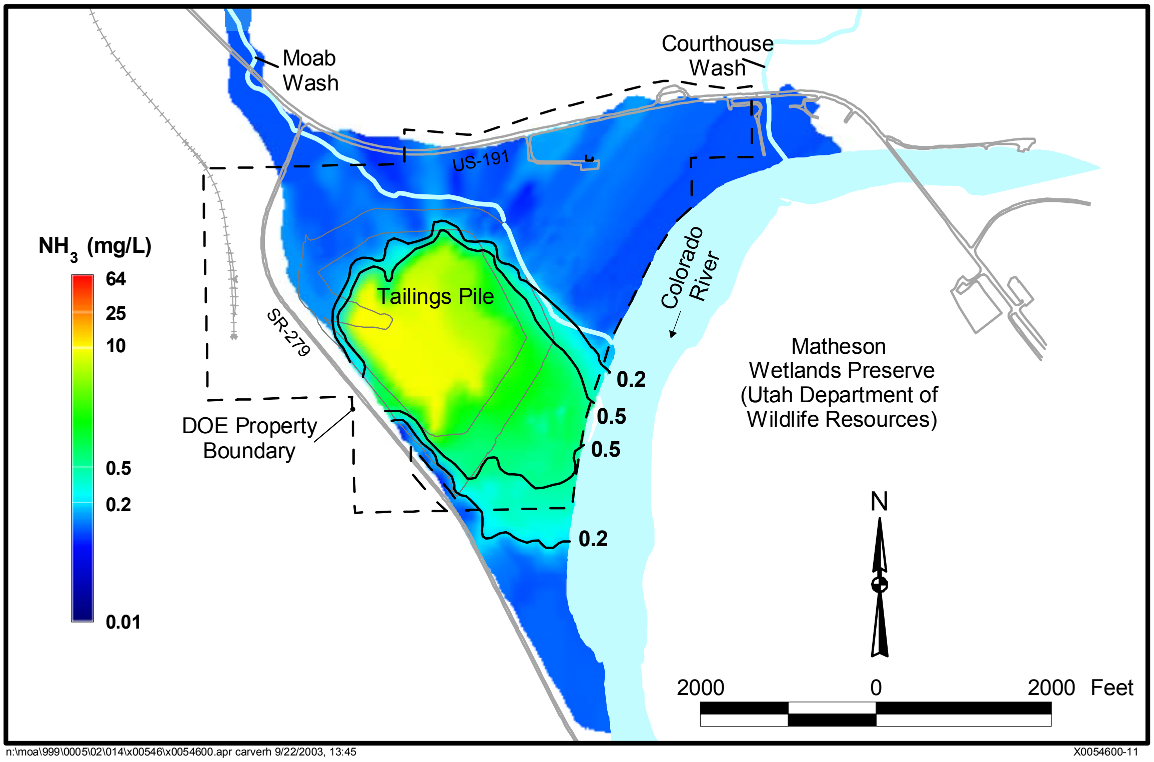

Figure 4–3. Predicted Ammonia Concentrations in the Ground Water After 200 Years for the On-Site Disposal Alternative

Concentrations of treated ground water that would be reinjected into the aquifer would depend on the treatment options, as discussed in Section 2.3.2.1, but would not adversely affect ground water quality or human health. If reinjection were selected, contaminated ground water would be disposed of in accordance with state underground injection control regulations.

The potential exists in the long term (during and following active remediation) for ground water contaminant concentrations to be affected by a 100-year flood, similar to a flood that occurred in 1984, which was simulated to evaluate the impact of ammonia released to the Colorado River. On the basis of surveyed elevations of the tailings profile, river stage elevation measurements obtained during the 1984 flood, and physical properties of the tailings, the drainage volume is approximately 591,250 ft^3 (4,422,550 gallons, or 16,740,000 L). An average concentration of the tailings pore fluid of approximately 1,100 mg/L and an average drainage rate of the pore fluid of 307 gpm for 10 days would produce a source of approximately 1.8 million grams of ammonia per day. Model results suggest that near the bank of the Colorado River, the maximum ammonia concentration in ground water would increase by just over 2 mg/L in approximately 10 years after a 100-year flood. However, effects of the tailings inundation would decline rapidly over a period of approximately 20 years after the flood event.

4.1.3.2 Impacts from All Sources

Implementation of ground water remediation with application of supplemental standards would result in no adverse impacts to ground water and therefore would not adversely affect human health. In the long term, active remediation would reduce ammonia concentrations in ground water that are adversely affecting the Colorado River.

4.1.4 Surface Water

This section describes the short-term and long-term impacts to surface water that would result from on-site disposal of contaminated site and vicinity property materials. Impacts that could occur from remediation of surface materials and ground water are assessed assuming that the final disposal cell would be in the same location as the existing tailings pile. The impacts analysis is based on the proposed action and alternatives described in Sections 2.1 and 2.3 and the affected environment as described in Section 3.1.7. Section 4.1.4.1 discusses the impacts that would result from construction and operations. Section 4.1.4.2 discusses impacts associated with remediating vicinity properties. No impacts to surface water at the Moab site are anticipated as a result of transporting vicinity property materials to the site, or as a result of maintenance and operations following surface remediation. Therefore, these aspects are not discussed further. Section 4.1.4.3 summarizes the impacts from all sources for later comparison of impacts between the alternatives. Section 4.1.17 discusses potential impacts as a result of a post-remediation catastrophic event.

4.1.4.1 Construction and Operations Impacts at the Moab Site

In the short term, surface-disturbing activities, including removing tamarisk, excavating contaminated soils, regrading the disposal cell, realigning Moab Wash, and placing vicinity property materials on the site, present the potential for increased contamination and sediment runoff to the Colorado River and Moab Wash. However, no significant adverse impacts to surface water are anticipated because site controls and a storm water management plan would be implemented as described in Chapter 2.0. Enforcement of the plan would be shared jointly by DOE, the State of Utah, and, when applicable, the Corps of Engineers. Likewise, fuel storage areas would be managed and controlled in accordance with state regulations to prevent the release of petroleum products to surface waters. Withdrawal of surface water for clean water applications, as described in Section 2.3.2.4, and for dust control would be within the water rights granted by the State. Any work within Moab Wash or the Colorado River high water mark would be completed in accordance with a Clean Water Act Section 404 permit.

Concentrations of ammonia in surface water can exceed federal and state ambient water quality criteria in some locations at certain times. Contaminated ground water could continue to adversely affect surface water for up to 5 years after implementation of active ground water remediation (see Figure 2–42). However, interim actions, including DOE's proposed clean water application (Section 2.3.2.4), are being implemented and could be implemented periodically to reduce ammonia concentrations and minimize adverse effects to surface water quality.

An analysis of ground water impacts (Section 4.1.3) shows that ammonia concentrations in ground water would decrease through natural processes (e.g., adsorption, geochemical degradation, dispersion) until a steady-state concentration was reached. Surface water concentrations should decrease as well. For the on-site disposal alternative, this steady-state concentration is predicted to be approximately 0.7 mg/L, which is approximately a factor of 1,000 less than current concentrations. The correlation between ground water and surface water concentrations is expected to result in a similar decrease in surface water concentrations as well.

Long-term impacts to surface water as a result of active ground water remediation would depend on the extraction, treatment, and disposal options selected. The proposed active remediation would control ground water discharge to the river while natural processes reduced ammonia concentrations in the ground water to levels protective of aquatic species. After completion of active remediation, the potential does exist for a flood to slightly increase ammonia concentrations in ground water (Section 4.1.3.1), but this should have minimal impact to surface water concentrations.

Any treatment of contaminated ground water and discharge to surface waters, as described in Section 2.3.2, would be in accordance with state permitting requirements and therefore would not result in an adverse impact to Moab Wash or the Colorado River. Other treatment and disposal methods would also not adversely affect surface water.

Active remediation would be discontinued when ammonia concentrations in ground water reached acceptable levels that allow resumption of discharge to surface water (estimated at 80 years). At that time, discharge of ground water to the surface would have no discernible impact. However, concentrations of ammonia in surface water would probably remain above surface water background concentrations because of steady-state concentrations in ground water.

Storm water management during site reclamation would include berms between the site operational areas and the Colorado River and Moab Wash to ensure that the site is not inundated from flood events up to the magnitude associated with 25-year return intervals. Should a flood event of greater magnitude than this occur, there is a potential for tailings to be transported off the site and into the Colorado River and Moab Wash. Disposal alternatives that could involve on-site drying of tailings (i.e., off-site disposal via truck or rail haul) would have the potential for supplying a greater amount of tailings to flood waters than alternatives that do not involve on-site drying (i.e., off-site disposal via slurry pipeline or on-site disposal) should a flood greater than a 25-year return interval occur.

4.1.4.2 Impacts from Characterization and Remediation of Vicinity Properties

Surface water located close to vicinity properties could be affected by sedimentation and possibly by contaminant runoff. DOE would implement a storm water control plan for those properties.

4.1.4.3 Impacts from All Sources

Short-term impacts to surface water as a result of construction and operation at the site and from characterization and remediation of vicinity properties would not be expected to be adverse. However, elevated contaminant levels in ground water would continue to adversely affect surface water in the short term until active remediation of ground water reduced concentrations. Once active remediation was implemented, contaminant concentrations in ground water discharging to surface water would decrease to levels that would be protective of aquatic species. Following completion of active remediation, levels would be expected to remain protective.

4.1.5 Floodplains and Wetlands

Impacts that could result from surface remediation are assessed with the assumption that the final disposal cell would be in the same location as the existing tailings pile. The impacts analysis is based on the proposed alternative action described in Section 2.1 and the affected environment as described in Sections 3.1.8 and 3.1.9. Impacts for this alternative are more thoroughly discussed in the floodplain/wetlands assessment (Appendix F).

4.1.5.1 Construction and Operations Impacts at the Moab Site

Soil excavation and removal of contaminated materials during surface remediation of the former millsite would occur within the 100- and 500-year floodplains. Removal of soils may permanently lower the elevation of the floodplain, resulting in greater exposure of the base of the pile (currently underground) to flood waters, increased capacity of the floodplain, and possible changes to flooding patterns at the Matheson Wetlands Preserve.

Rechanneling Moab Wash would affect the floodplain in the short term by changing drainage patterns and the river discharge point and by increasing runoff to the river. However, storm water management measures could also decrease the amount of water and sediment entering Moab Wash. In the long term, the realignment of Moab Wash would reduce the potential for storm water to affect the disposal cell. The wash would still enter the river upstream of endangered fish habitat, but its rechanneling could alter flow patterns and disrupt downstream wetlands. These effects would be long-term, and such action would require federal and state permits.

The proposed removal of the tamarisk and other vegetation adjacent to the river would be an adverse, short-term impact to the stability of the floodplain and wetlands until revegetation was complete.

The buried riprap wall would stabilize the soil in the floodplain. Therefore, an adverse impact would not be expected.

4.1.5.2 Impacts from Characterization and Remediation of Vicinity Properties

Vicinity properties may be located within the Colorado River, Pack Creek, or Mill Creek floodplains. If these sites are located within floodplains or wetlands, short-term impacts could result. Remediation would include excavating and transporting contaminated materials from vicinity properties to the Moab site. Because DOE would implement site controls (e.g., storm water management) and obtain necessary federal and state permits to control potential impacts during remediation, any short-term impacts to floodplains or wetlands would be expected to be minimal. Reconstruction and revegetation at vicinity properties would be consistent with the existing use of the property. Therefore, there would be no long-term impacts to floodplains or wetlands.

4.1.5.3 Construction and Operations Impacts Related to Transportation

Because existing roads would be used to transport contaminated materials from vicinity properties to the Moab site, no adverse impacts to floodplains and wetlands would be expected. New proposed routes from borrow areas would be investigated for wetlands prior to construction. Impacts would be avoided wherever possible by rerouting roads to bypass these areas. In the long term, disturbed areas would be restored to their previous condition, or as agreed to with the appropriate land management agency.

4.1.5.4 Impacts from All Sources

Long-term and short-term impacts would be associated with rechanneling Moab Wash and with remedial activities at the Moab site. Only short-term impacts would occur from characterization and remediation of vicinity properties and from constructing or updating transportation routes.

4.1.6 Aquatic Ecology

The aquatic resources within the vicinity of the Moab tailings pile are associated with the Colorado River. This assessment of environmental consequences focuses on the aquatic plants and animals in the river and on the shore between the site and the river. Potential impacts are discussed in terms of direct and indirect effects to individuals and populations, and the potential impacts to their habitat.

This section describes the short-term and long-term impacts to aquatic ecology, including receptors, that could result from on-site disposal of contaminated site and vicinity property materials. Section 4.1.17 discusses potential post-remediation impacts to aquatic species as a result of a catastrophic event. Adverse impacts could be a result of physical (e.g., mechanical disturbance, habitat alteration), chemical (e.g., ammonia contamination), and radiological influences. Of these, chemical influences from the adjacent ground water plume would be of greatest concern in the short term until active remediation reduced risk to aquatic species, especially endangered species. Federally listed species that could be potentially affected by both surface and ground water remedial actions include the endangered Colorado pikeminnow, razorback sucker, humpback chub, and bonytail.

Detailed discussion of impacts to endangered species is presented in Appendix A1, "Biological Assessment."

Impacts in this section are assessed with the assumption that (1) the disposal cell would be located in the same place as the existing tailings pile, and (2) the location of the legacy plume would not be affected by surface remediation activities. The impacts are based on the proposed action and alternatives described in Sections 2.1 and 2.3 and the affected environment as described in Section 3.1.10. Adverse impacts to surface water would not be expected to occur from transportation activities or monitoring and maintenance. Therefore, these activities are not discussed further in this section. It is expected that active remediation would be protective of aquatic species at the individual, population, and community levels of the Colorado River ecosystem**.**

4.1.6.1 Construction and Operations Impacts at the Moab Site

Mechanical Disturbance. The impact to aquatic species due to construction and operations at the Moab site would be from mechanical disturbances and loss of vegetation along the shoreline of Moab Wash and the Colorado River. Activities at the Moab site would likely disturb about 8,100 ft of Colorado River shoreline. The vegetation along the shoreline, consisting primarily of tamarisk, would be removed in order to excavate and remove contaminated soils (RRM). The tamarisk along the banks of Moab Wash as it enters the Colorado River would likely be removed as well.

The effects of mechanical disturbance would include the loss of shade and cover over the shoreline and potentially a loss of surface stability that could lead to increased erosion and siltation into the wash and river. Impacts to aquatic species due to these changes would be minimal. The shade and cover provided by the tamarisk is only along the edge of the river during high and moderate flows of the river. At low river flows, the shoreline vegetation provides no shade, and the flow into the wash is cut off. The potential also exists for water intake structures in the river to result in mortality to eggs, larvae, young-of-the-year, and juvenile fish life stages. DOE would minimize this potential by using one-quarter to three-eighths inch screened mesh on water intake structures.

Effects from siltation and erosion into the river and wash could fill in backwater areas that may be important to macroinvertebrates and fish. Moab Wash has been documented as potential pikeminnow nursery habitat that could be affected by siltation and erosion (NPS 2003). Erosion along the river shoreline could create new backwater areas, but these would likely be temporary and depend on river stage.

Federally listed species that could be potentially affected by the changes to the shoreline include the endangered Colorado pikeminnow, razorback sucker, humpback chub, and bonytail. The Colorado River reach near the Moab site has been designated as critical habitat (50 CFR 17.95) for all four federal endangered fish species. Juvenile and adult Colorado pikeminnow, stocked adult razorback sucker and bonytail have been collected near the Moab site. Moab Wash and the riparian vegetation adjacent to the Colorado River potentially provide nursery habitat for young-of-the-year fish (NRC 1999, NPS 2003, UDWR 2003). Erosion and siltation events that change the depth and configuration of these backwater areas are likely to affect the extent of nursery habitat for endangered fish. Other fish, macroinvertebrates, and emergent plants associated with the backwater areas are also likely to be affected by erosion and siltation. The effects of erosion and siltation would be prevented or reduced by minimizing shoreline disruption, replacing vegetation, and installing erosion control devices.

Noise. Noise from site construction and operations is not expected to affect the aquatic environment. Activities along the shoreline are likely to be of short duration and are not likely to cause macroinvertebrate or fish communities to avoid the area.

Other Human Disturbances. Aspects of human presence such as personnel or vehicle movement and supplemental lighting are not expected to affect the aquatic environment.

Water depletion in the Colorado River as a result of remediation of the Moab site would be in accordance with the Cooperative Agreement to implement the “Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin” (USF&WS 1987). The Cooperative Agreement was signed by the Secretary of the Interior and by the governors of the states of Colorado, Utah, and Wyoming. The Recovery Program requires that all Section 7 consultations address depletion impacts. A key element of the program requires a one-time contribution of $10 per acre-foot (adjusted annually for inflation) based on the average annual depletion through activities at the site, to be paid to USF&WS. The balance of the payment would be due at the commencement of construction at the site. The impacts due to water depletion can be offset by the one-time contribution, appropriate legal protection of instream flows pursuant to state law, and accomplishments of activities necessary to recover the endangered fish as specified in the Recovery Plan (NRC 1999). Further consultation would be necessary to determine any required permits and the financial contribution based on water depletion.

Effects of Flooding on Ground Water Remediation. Although effects of catastrophic flooding to the pile are considered in Section 4.1.17, there is also the possibility that flooding could affect the aquatic environment by interrupting ground water remediation. The interim action and proposed ground water remediation includes wells and pumps, or shallow trenches located between the foot of the pile and the river's edge (Section 2.3). Impacts to the aquatic environment could occur because of flooding of the remediation systems. As discussed in Section 3.1.8, the location for these systems is in the 100-year floodplain. If a flood were to inundate the remediation systems, contaminated ground water from the wells or trenches could be carried into the river. DOE expects that remediation systems would be quickly restored after the flood waters receded. USF&WS would be notified if ground water remediation systems were shut down because of flooding, and monitoring of the river environment would take place to determine if the concentrations of contaminants of concern exceed aquatic benchmark values.

Temperature. Temperature can influence the development, metabolism, motility, and mobility of fish; affect the expression of other environmental factors; and destroy the integrity of a fish, causing its death (Beitinger et al. 2000). Impacts associated with activities related to remediation would not be expected to influence the temperature of the Colorado River. Leachate from the tailings pile travels through ground water into the river, and the temperature gradient is not expected to affect the aquatic environment.

Chemical Impacts to Aquatic Species. The tailings pile on the Moab site is the source of chemical contamination to ground water, which in turn is the source of contamination in the Colorado River.

The aquatic environment near the site has been characterized in Chapter 3.0. Characterization has included sampling sediment, fish tissue, and surface water near the Moab site and upstream background surface water. Sediment samples of the Colorado River were collected from 1995 through 1997; however, these samples were not considered in this analysis because of comments in the Final Biological Opinion in NRC's final EIS (NRC 1999) concerning the quality of the data for evaluation of impacts. Concerns for the quality of the sediment data include inappropriate procedures and protocols for sample collection and inadequate collection of samples for statistical evaluation. Fish were collected for tissue analyses from 1995 through 1997, and results of the fish tissue analyses also were not considered in this analysis because of comments similar to those made about the data quality of sediment samples (NRC 1999). An evaluation of the means and standard deviations for all the combined fish tissue data does not show a strong statistical difference in concentrations in the tissues collected upstream of the Moab site compared to those collected downstream.

The screening of contaminants is presented in Appendix A2 of the EIS and summarized here. The screening is based on surface water samples collected by Shepherd Miller, Inc. (SMI), DOE, and USGS. Samples were collected by SMI and DOE from 2000 through 2002. These data are presented in Appendix D of the *Site Observational Work Plan for the Moab, Utah, Site* (DOE 2003a). Water sample data were collected by USGS from 1998 through 2000 and are presented in *A Site-Specific Assessment of the Risk of Ammonia to Endangered Colorado Pikeminnow and Razorback Sucker Populations in the Upper Colorado River Adjacent to the Atlas Mill Tailings Pile, Moab, Utah* (USGS 2002). Many of the samples from other studies were considered, but quality issues were discovered during the evaluation of data for surface water samples taken prior to 2000. These issues included insufficient information to determine the location of the analyzed sample and laboratory quality control and quality assurance questions. Contaminants of potential concern for the Moab site were identified from institutional knowledge about the uranium milling processes used during operation of the Atlas mill and from the NRC EIS (NRC 1999). Surface water monitoring data were evaluated to determine if maximum concentrations were above detection limits, background levels, and federal and state criteria (i.e., benchmarks) for surface water quality.

Impacts to aquatic organisms can result from either acute or chronic exposures to contaminants of potential concern (Appendix A2). An acute exposure is defined as “the highest concentration of a material in surface water to which an aquatic community can be exposed briefly without resulting in an unacceptable effect” (EPA 2002). A chronic exposure is defined as “the highest concentration of a material in surface water to which an aquatic community can be exposed indefinitely without resulting in an unacceptable effect” (EPA 2002). Currently, the State of Utah criteria include an acute, 1-hour exposure and a chronic, 4-day exposure. Suter and Tsao (1996) were used where state and federal standards were not available. However, they used a method, referred to as Tier II, to establish criteria for aquatic benchmarks using fewer data than required by EPA in the NWQC. Also, they developed estimated lowest chronic values for fish extrapolated from laboratory studies. The standards are discussed further in Appendix A2 of the EIS.

Based on the evaluation of contaminants of potential concern in Appendix A2, the contaminants that would require further assessment and continued monitoring during ground water remediation for the Moab site are ammonia, copper, manganese, sulfate, and uranium. If active ground water remediation near the Colorado River were conducted, the maximum concentrations of these contaminants of concern where the ground water enters the river (nearshore environment) would decrease to levels below acute and chronic benchmarks. It is DOE’s position that if acute criteria can be met everywhere, then chronic criteria can be met outside the mixing zone (Section 2.3.2). In addition, available data regarding interaction of ground water and surface water indicate that concentrations of most constituents decrease significantly as ground water discharges to and mixes with surface water (a 10-fold decrease is observed on average). Consequently, there is a reasonable assurance that protective surface water concentrations could be achieved by meeting less conservative goals than chronic standards in ground water. DOE believes that a target goal of 3 mg/L in ground water (the low end of the reasonable acute range) would provide adequate surface water protection. The 3-mg/L concentration represents a 2- to 3-order-of-magnitude decrease in the center of the ammonia plume and would be expected to result in a corresponding decrease in surface water. Coupled with the average 10-fold dilution and the tendency for ammonia to volatilize, this value should result in compliance with both acute and chronic ammonia standards in the river everywhere adjacent to the site. Therefore, DOE proposes to use the 3-mg/L concentration of ammonia as a target goal for evaluating ground water cleanup options. Potential synergistic effects between contaminants would be reduced through ground water remediation. Continued monitoring during ground water remediation would be necessary to verify that contaminant concentrations remained below both acute and chronic benchmarks for aquatic species.

Radiological Impacts to Aquatic Species. The primary source of radioactive contamination in the aquatic environment at the Moab site is ground water. The routes of exposure for the radioactive contaminants are the same as those for chemical contaminants. The contributors to radiological dose to the aquatic organisms at the Moab site that have been monitored include lead-210, polonium-210, radon-222, radium-226, radium-228, thorium-230, uranium-234, and uranium-238, and the general indicators of radionuclides, gross alpha and gross beta.

The RESRAD Biota Code (Version 1.0 Beta 3, June 3, 2003) was used to screen the dose rate to aquatic organisms based on the maximum observed concentrations of uranium-238, uranium-234, and radium-226 (DOE 2002b). These isotopes represent the highest values analyzed for radionuclides from 2000 to 2002. The protocol for screening assessment includes multiple tiers. The first-tier screening assessment using the maximum observed concentrations had a sum of fractions that equaled 3.16, which exceeded the DOE guidance level of 1.0 for aquatic biota. A second-tier analysis based on mean concentrations of these three radionuclides of those values above detection resulted in a sum of fractions value of 0.29. The results of the second-tier analysis indicate that dose rates are below the 1.0-rad-per-day guidance level adopted by DOE for screening dose rates to aquatic organisms.

Results of the RESRAD assessment indicate that the actual dose rates to aquatic organisms are below a population effect level. There are no guidelines for radiological effects to individuals, which is important in evaluating impacts to threatened and endangered species. The studies that were completed for the 1.0-rad-per-day criterion were based on exposures to organisms for 1 year, and then normalized to a dose rate based on a day. One can interpret these results to mean that a dose rate of 1.0 rad per day, if sustained for a year, would have an effect on some individuals but not on the population as a whole. Based on monitoring results from 2000 to 2002 and on the life styles of the endangered fish around the Moab site, radiological effects currently are not expected to adversely affect the aquatic environment.

In another study, the USGS concluded that there would be “no significant biological impacts to fish populations caused by radionuclide concentrations sampled in the Colorado River and sediments.” It found that “radiochemical concentrations are elevated in ground water below the Moab pile; however, these waters do not result in a high radiation exposure to fish” (USGS 2002).

Ground water extraction near the Colorado River and the use of freshwater injection would further decrease the maximum concentrations of radionuclides in the shoreline of the Moab site. These activities would be necessary for reducing impacts from chemical contaminants. They would also reduce the potential for radiological effects to individuals, which is important to endangered species as well as populations.

4.1.6.2 Impacts from Characterization and Remediation of Vicinity Properties

Some vicinity properties may be close to surface water. In the short term, the potential exists for sedimentation, erosion, and alteration of habitat. However, the potential for adverse impacts would be minimal because of engineering and site controls for storm water runoff. As previously discussed, removal of vegetation in riparian areas could alter habitat and reduce stream cover and shade. However, few, if any, vicinity properties would likely be within surface waters or quality habitat for aquatic species. Consequently, any effects on aquatic biota from characterization and remediation of vicinity properties would likely be very small and of short duration (i.e., a few weeks) at each site.

4.1.7 Terrestrial Ecology

Appendix A1, "Biological Assessment," presents a detailed discussion of federally listed species that would be affected in the vicinity of the Moab site.

4.1.7.1 Construction and Operations Impact at the Moab Site

Habitat Loss. Under the on-site disposal alternative, the primary impact to terrestrial species and habitats due to construction and operations at the Moab site would be the mechanical disturbance and the resulting loss of vegetation and habitat. Activities at the Moab site would disturb approximately 439 acres within the site boundaries. Although most of the Moab site has very little to no vegetation, approximately 50 acres of habitat in the southern corner of the site is currently dominated by a relatively dense stand of tamarisk that would be lost in order to remove contaminated soil. The effects of this mechanical disturbance would include the loss of foraging and breeding habitat for various wildlife species, loss of shade and cover, including the areas near the Colorado River shoreline, and potentially a loss of surface stability that could lead to increased erosion and siltation.

Federally listed species that could be potentially affected by the habitat loss include the endangered southwestern willow flycatcher. The only federal candidate species that could be so affected is the western yellow-billed cuckoo. On 12 May, 24 June, and 10 July 2004, DOE and the UDWR conducted field surveys of this tamarisk habitat and no flycatchers were detected. Further, UDWR concluded that this tamarisk constitutes only marginal nesting habitat at best (UDWR 2004b). Although, flycatchers did not breed in this habitat in 2004, it does not preclude them from breeding there in subsequent years. In addition, the southwestern willow flycatcher could potentially occur in the Matheson Wetlands Preserve across the Colorado River from the Moab site and several miles downstream from the Moab site (NRC 1999, USGS 2002). It could thus also use the Moab site for foraging or as stopover habitat during migration. Because the cuckoo has been known to nest across the river in the Matheson Wetlands Preserve (USGS 2001), it also could potentially use this tamarisk habitat for foraging. If this were the case, removal of this habitat still would only minimally affect cuckoos, if at all.

Other riparian birds also could be affected by the habitat loss as well as some species of mammals, reptiles, and amphibians. It is unlikely that removal of the 50 acres of tamarisk habitat would have a significant effect on the populations of any wildlife species in the Moab site vicinity, especially with the presence of hundreds of acres of similar habitat across the river in the Matheson Wetlands Preserve.

The effects of habitat loss would be of relatively short duration, especially if vegetation were replaced upon completion of surface cleanup. There could be a long-term benefit if the tamarisk were replaced with more desirable vegetation (such as willows) that would provide higher quality habitat for a greater number of species. Other measures that could be employed to reduce impacts include scheduling the removal of vegetation outside the nesting season and migration periods, minimizing the area of disturbance to the extent practical, and using best management practices for runoff and sediment control.

Noise. Noise from site construction and operations could have adverse impacts on terrestrial biota in the vicinity of the Moab site. Man-made noise can affect wildlife by inducing physiological changes, nest or habitat abandonment, or behavioral modifications, or it can disrupt communications required for breeding or defense (Larkin 1996). In contrast, wildlife may also habituate to man-made noise (Larkin 1996). Much of the available effects data focus on noise sources more extreme than construction activities, such as aircraft overflights (Efroymson et al. 2000), and most of the existing data are species-specific. Consequently, only a general evaluation of potential noise impacts at the Moab site is possible without specific knowledge about the locations of species relative to the noise source and without specific data on the responses of the same species to construction noises.

As described in Section 4.1.10, the maximum noise level generated by construction equipment at the Moab site would be estimated to be approximately 95 dBA measured at 49 ft. This noise level would decrease with distance, until it reached a daytime background level of approximately 65 dBA at 1,476 ft from the source (65 dBA is the normal daytime background level in Moab). If additional vegetation were removed from the site as part of construction operations, the effects of elevated noise levels on wildlife should be minimal, because wildlife would already have been displaced by the habitat removal discussed above. Further, there could be detectable elevated sound levels in habitats downstream and across the river resulting from work near the periphery of the site.

The southwestern willow flycatcher and threatened bald eagle are the only federally listed species that could be present near the periphery of the site and therefore could be affected by noise from site operations. The western yellow-billed cuckoo is the only federal candidate species that could be present near the periphery of the site and could also be affected. The willow flycatcher does not appear to be overly sensitive to low-level human activity outside of its breeding territory (USF&WS 2002). Typical mitigation measures that have been employed to minimize impacts to breeding willow flycatchers include limiting equipment use within about 300 to 1,000 ft of occupied territories (CDFG 2002). Consequently, it is unlikely that off-site southwestern willow flycatchers would be significantly affected by construction activities at the Moab site. The bald eagle is often more sensitive to human presence and noise than other species. However, it is not known to nest or night roost at the Moab site and is not commonly seen in the vicinity of the site, and it is therefore is unlikely to be affected by noise from site operations. Information on the response of yellow-billed cuckoo to noise is insufficient to evaluate potential impacts on this species.

Other Human Disturbance. Other aspects of human presence, such as personnel or vehicle movement and supplemental lighting, could have an effect on local wildlife under the on-site disposal alternative. However, because essentially all usable habitat at the Moab site would be removed as part of construction operations, it is doubtful that these factors would cause significant adverse impacts to wildlife at the site. Impacts to off-site populations could be minimized by limiting activities near the site periphery, pointing lights downward, or installing canopies to limit the amount of light beyond the site boundary.

Erosion. Runoff and erosion could affect terrestrial systems by damaging surface vegetation and by siltation of wetlands, which could disrupt breeding habitat for amphibians and insects. During operations, erosion could result from movement of vehicles and materials. In general, these effects could be minimized using standard best management practices to control erosion and sedimentation. In the long term, a disposal cell could result in significant erosion and sedimentation and could disturb recovering vegetation at the site. The potential for this to occur would be minimized by design requirements and site storm water runoff controls. This would tend to have a greater impact on aquatic rather than terrestrial ecology.

Chemical/Radiological Impacts from Contaminants in Surface Water. Because of the complexity of the analysis of these impacts, only a brief conclusion is presented here. Appendixes A2 and A1 present more detailed discussions.

There is no potential risk of chemical or radiotoxic effects for riparian vertebrates, including federally listed species that could potentially occur at the Moab site (southwestern willow flycatcher, western yellow-billed cuckoo, and bald eagle), from chemical or radioactive constituents in surface water under the No Action alternative. Consequently, there would be no effects under the on-site disposal alternative, since chemical and radionuclide concentrations would likely be reduced.

There is a potential risk of toxic effects to riparian plants from chemical constituents in surface water under the No Action alternative, assuming plant roots are in contact with the freshwater aquifer or associated soil water above it. However, such effects would be unlikely under the on-site disposal alternative, since chemical concentrations would likely be reduced. There would be no phytotoxic effects to federally listed plant species (Jones' cycladenia, Navajo sedge, and clay phacelia), since these are not known to occur on or near the Moab site.

There is no potential risk of radiotoxic effects to riparian plants from radioactive constituents in surface water under the No Action alternative. Consequently, there would be no effects under the on-site disposal alternative, since radionuclide concentrations would likely be reduced. There would also be no radiotoxic effects to Federally listed plant species (Jones' cycladenia, Navajo sedge, and clay phacelia), since these are not known to occur on or near the Moab site.

Wildlife Exposure at Evaporation Ponds. One of the effluent treatment technologies under consideration is solar evaporation. Solar evaporation consists of pumping extracted ground water into large membrane-lined ponds built into the floodplain, allowing the water to evaporate naturally, and disposing of accumulated solids. Pond(s) would need to be of sufficient size that evaporation rates could keep up with extraction rates and complete remediation in a reasonable time frame. Estimated pond areas range up to 40 acres, and a total of 60 acres of land would need to be disturbed. This would include some type of support facility, but the facility would be expected to be small and would probably be located in already disturbed areas.

Potential impacts that could result from construction and operation of an evaporation pond include floodplain habitat disturbance and wildlife displacement/destruction or contaminant impacts. Habitat disturbance and wildlife displacement/destruction could be minimized by selecting a site in an area that has been previously disturbed or otherwise has relatively little habitat value and by avoiding clearing land during the nesting season of migratory birds. Evaporation ponds could attract wildlife that may be exposed to contaminants through ingestion of contaminated prey and water, dermal uptake of contaminated water and airborne contaminants, and inhalation of airborne contaminants. In addition to impacts from exposure, wildlife could transport contamination off site.

The bald eagle, southwestern willow flycatcher, and western yellow-billed cuckoo are the only federally listed species considered to be potentially present at the Moab site and that could thus be affected by an evaporation pond. The evaporation pond would be located in an area that has been previously disturbed and is generally devoid of vegetation (e.g., that could be used by bald eagles to perch in and flycatchers and cuckoos to forage in). Vegetation around the evaporation pond, if any, would be maintained in such a state that it would remain unattractive to these species. Further, the pond would also be located in an area where project activities and site maintenance operations would create continual disturbance. Consequently, the probability of visits from these three species to the pond would be expected to be low. Nevertheless, the pond would be qualitatively monitored for general wildlife use. If it were determined that one or more of these three species were frequenting the evaporation pond, techniques to minimize or eliminate use would be identified and implemented. Techniques may include deterrents such as noise (e.g., propane boom cannons), visual deterrents (e.g., reflectors, silhouettes, effigies, water color), or obstruction (e.g., netting).

Animal Intrusion into the Moab Tailings Pile. Because the barrier that would cover the Moab tailings pile would be designed to prevent animal intrusion, wildlife exposure to the tailings would not be expected.

4.1.7.2 Impacts from Characterization and Remediation of Vicinity Properties

Under the on-site disposal alternative, mechanical disturbance and a potential loss of vegetation and habitat would occur during remediation at the vicinity property sites. Each site would likely be small (average approximately 2,500 ft^2; see Section 2.1.2.2). Therefore, the magnitude of physical disturbance at each site would likely be small. This disturbance could result in minor habitat loss for some wildlife species and could potentially disturb populations of rare plant species. However, few if any of the vicinity properties would likely be in native condition or represent quality habitat for wildlife.

Activities at the vicinity property sites could affect wildlife in the surrounding area by introducing noise and increased human presence. However, most of the vicinity property sites are located close to human habitation or regular human activities, so most wildlife in the vicinity would likely be habituated to human presence. The quantity and scale of the equipment used (backhoes, graders, dump trucks) would be similar to that used in typical small-scale construction projects. There is a low probability for diesel or oil spills, and these would likely be quickly controlled and remediated. Consequently, the effects on terrestrial organisms from characterization and remediation of vicinity properties would likely be very small and of short duration (i.e., a few weeks) at each site.

4.1.7.3 Construction and Operations Impacts Related to Transportation

Under the on-site disposal alternative, the transportation of vicinity property and borrow materials to the Moab site could affect terrestrial organisms either through direct mortality (e.g., collisions) or indirectly through noise. The magnitude of impacts for both of these factors would be related to the number of trucks trips required to haul the materials and the total number of miles traveled by those trucks. As indicated in Table 3−15, over 2,800 vehicles per day travel on US-191 north of Moab, and at least 3,000 per day travel on US-191 south of Moab. The estimated increase in traffic associated with the on-site disposal alternative is discussed in Section 4.1.16. The increase in traffic could increase the number of animals killed or injured in collisions with vehicles, especially on US-191, the major artery that would carry commuters and on which borrow and vicinity property material would be transported. The likelihood of increased collisions with wildlife would be greatest during seasons when material transportation or commuting would occur before sunrise or after sunset.

Several types of animals are typically involved in vehicle collisions; most noticeable are large ungulates such as deer, pronghorn antelope, and bighorn sheep. Less noticeable but more prevalent are snakes, lizards, and small mammals. Bighorn sheep have been reintroduced into Arches National Park, and individuals are now occasionally seen near US-191 north of Moab. The increased truck traffic to haul borrow materials to the Moab site would probably slightly increase the number of bighorn sheep killed in that area.

The bald eagle is the only federally listed species that could incur an increase in traffic-related mortality. The Utah Gap Analysis (UDWR 1999) indicates that potential high-quality bald eagle wintering habitat exists throughout many of the project areas. Indeed, bald eagles could be found temporarily and infrequently using such areas when there are opportunities to feed on carrion, such as in big-game wintering areas or in prairie dog colonies. Therefore, it is possible that if traffic-related wildlife mortality increased due to the project, an increased number of eagles could be hit on highways. However, without data on this relationship, it is reasonable to assume that the number of eagles hit on highways would be proportional to the number of carrion available. The increase in the number of traffic-related wildlife mortalities is expected to be small. Consequently, the potential increase in associated eagle deaths is also expected to be small.

Transportation of vicinity property and borrow materials would also increase noise on US-191 because of increased truck traffic. Average background noise levels along US-191 are approximately 70 dBA measured at 49 ft, which is likely detectible to humans up to approximately 6 miles from the road (Section 3.1.14). As described in Section 4.1.10, the increased truck traffic due to hauling borrow materials would likely increase the average noise level by approximately 2 dBA at 49 ft from the highway. This difference in noise level is essentially imperceptible to humans and would not be noticeable as different from baseline conditions within several hundred yards.

The primary federally listed species that could be affected by this increased traffic noise would be the threatened Mexican spotted owl. Data provided by UDWR (2003) indicated that there were no occurrences of the Mexican spotted owl in any of the project areas. However, habitat models (BLM 2003) indicate that potential habitat areas may exist in the canyons near US-191 over the first 7 miles north from the Moab tailings pile. Nonetheless, these models are primarily based on physical and topographic features and do not consider vegetation requirements. Mexican spotted owls nest, roost, and forage in an array of different community types, but mixed-conifer forests dominated by Douglas fir and/or white fir are most common (USF&WS 1995). However, they may also nest, but less frequently, in arid, rocky, mostly unvegetated canyons (Romin 2004). Although there are no forested areas in the vicinity of US-191 north of Moab, there are arid canyons that largely or altogether lack forest-type vegetation. Thus, it is unlikely but possible that spotted owls occur in the canyons near US-191 over the first 7 miles north of the Moab site. If present, the species could be disturbed by noise from increased truck traffic. The area in the vicinity of this section of transportation corridor constitutes a very popular recreation area, with heavy use by off-highway vehicles and mountain bikes. Although the increase in truck traffic noise could be detectable up to several miles from the highway, the existing off-highway vehicle noise and associated human presence would likely have a greater and more direct impact on the owls.

The likelihood of adverse impacts from either vehicle collisions or increased noise levels would be greater at night than during the day. For example, deer are typically more active at dawn and dusk than during the day and are therefore more likely to be hit at that time. Highway noise would likely be detectable from farther away at night because of reduced levels of background noise. The vehicle collision and noise impacts of transportation would return to previously existing conditions at the completion of activities at the Moab site, and no long-term effects would be expected.

4.1.7.4 Monitoring and Maintenance Impacts

Routine post-closure monitoring and maintenance of the Moab site would not be expected to have any impacts to terrestrial species or habitats. However, in the event that major corrective actions were needed, some of the recovering vegetation on and around the disposal site could be disturbed.

4.1.7.5 Impacts from All Sources

Overall impacts to terrestrial ecological resources under the on-site disposal alternative include approximately 50 acres of tamarisk habitat loss at the Moab site (the rest of the site is considered to have zero habitat quality) and a maximum of approximately 550 acres of desert habitat at the borrow sites (assuming use of Floy Wash for cover soils and Klondike Flats for radon barrier soils). Additional habitat would be lost at the commercial quarry sites for sand, gravel, and riprap. Habitat value would decrease slightly near US-191 because of the increased truck traffic required to haul borrow materials, and traffic-related wildlife mortalities would increase slightly because of increased traffic.

4.1.8 Land Use

Under the on-site disposal alternative, impacts to land use would include potential changes to existing land use at the site or to nearby properties.

4.1.8.1 Construction and Operations Impacts at the Moab Site

Construction and operations at the Moab site, which is currently under federal ownership and control, would not alter the existing land use at the site. Noise and vibrations that could occur as a result of these activities would be unlikely to travel off the site and thus would be unlikely to affect the use of adjacent property or nearby recreational areas (see also Section 4.1.10). Following surface remediation, ground water contamination would remain beneath the site, and DOE would operate a ground water treatment facility until ground water cleanup goals were met, estimated to be 80 years. The land occupied by the mill tailings pile would remain under federal ownership and control in perpetuity, creating a long-term loss of that acreage for beneficial land use by other government or private owners.

4.1.8.2 Impacts from Characterization and Remediation of Vicinity Properties

Under the on-site disposal alternative, remediation of vicinity properties could result in short-term displacement of some families or businesses if relocation were necessary during the removal of contaminated materials from properties. It is unlikely that contamination at any vicinity property would be extensive enough to cause it to be left in place, thereby requiring a change of land use or implementation of access or use restrictions.

4.1.8.3 Construction and Operations Impacts Related to Transportation

All vicinity property material and borrow material would be transported to the Moab site by trucks using existing roadways. No additional road construction or road improvement is expected to be necessary. Noise and traffic disruptions could occur as a result of the transport of these materials; such disruptions could temporarily disturb residents, businesses, and recreational users along the travel routes (see Sections 4.1.10 and 4.1.16) and temporarily affect current uses of the property. These impacts would last for the duration of remediation at the Moab site.

4.1.8.4 Monitoring and Maintenance Impacts

Monitoring and maintenance activities at the Moab site would not affect land use as long as the site remained under federal ownership and control. No monitoring or maintenance would be expected for any of the vicinity properties.

4.1.8.5 Impacts from All Sources

Short-term, temporary land use impacts would be expected as a result of remediation of vicinity properties. Under the on-site disposal alternative, the land required for the disposal cell would remain in federal ownership in perpetuity. Additional acreage may be required to support ground water remediation infrastructure. Therefore, there would be no changes in land use from the current status in the foreseeable future. However, DOE would defer its decisions on the release and future use of the Moab site pending an evaluation of the success of surface and ground water remediation.

The long-term commitment of the Moab site for disposal would conflict with Grand County land use planning that designates the site as a "Specially Planned Area" (SPA) during remediation activities according to County Ordinance 346, but that envisions future land uses that would allow for low-density residential use upon completion of remediation.

4.1.9 Cultural Resources

This section addresses the potential for the disturbance of known cultural resources or the discovery of unknown resources under the on-site disposal alternative.

4.1.9.1 Construction and Operations Impacts at the Moab Site

Construction and operations at the Moab site would adversely affect some or all of the remaining structures and features associated with the historical uranium mill, which has been recommended for inclusion in the National Register of Historic Places, because they could be removed or dismantled during remediation. Most or all of the features associated with the historical mill are radioactively contaminated. At this time, it is not known which structures may be kept or dismantled. Also, it is not known if a collapsed log cabin, also recommended as eligible for inclusion in the National Register, would be removed or left in place; the radiological survey of this site has not yet been completed to determine if the materials or soils are contaminated. None of the other eligible cultural resources at or near the Moab site (including the one recorded traditional cultural property) would be affected by construction and operations at the site. DOE plans to consult with the State Historic Preservation Officer and other interested parties to determine mitigation measures for those millsite features that would be demolished. Mitigation measures might include (1) documenting and photographing the features in accordance with the

Utah State Historic Preservation Officer's standards, (2) providing historical information about the millsite and its operations to the Dan O'Laurie Canyon Country Museum in Moab, and (3) constructing a roadside turnout and erecting a kiosk containing historical information about the site.

Cultural resources located near areas of disturbance could be adversely affected indirectly through illicit collection, vandalism, or inadvertent destruction as a result of increased human activity in the area. DOE would require site workers to receive training on the need to protect cultural resources and the legal consequences of disturbing cultural resources.

4.1.9.2 Impacts from Characterization and Remediation of Vicinity Properties

Most of the vicinity properties are highly disturbed sites and would not likely contain significant cultural resources that could be affected by characterization and remediation of those properties. However, DOE would procure the services of a qualified and permitted professional archaeologist to assess the need to conduct Class III cultural resource surveys at Arches National Park, the Matheson Wetlands Preserve, and other properties as appropriate. If cultural resources eligible for inclusion in the National Register of Historic Places were located on a property and could be adversely affected, DOE would consult with the State Historic Preservation Officer and affected parties to determine mitigation measures.

4.1.9.3 Construction and Operations Impacts Related to Transportation

Impacts to cultural resources would not occur from construction and operations related to transportation because no new highway construction near the Moab site would take place.

4.1.9.4 Monitoring and Maintenance Impacts

Monitoring and maintenance activities under the on-site disposal alternative would not affect cultural resources.

4.1.9.5 Impacts from All Sources

Table 4–4 lists the total number of cultural sites eligible for inclusion in the National Register of Historic Places that could be adversely affected under the on-site disposal alternative.

Table 4–4. Number of Cultural Sites that Could Be Adversely Affected Under the On-Site Disposal Alternative

Location/Activity	No. of Cultural Sites Adversely Affected
Moab site (construction and operations)	0–2
Radon barrier material (Klondike Flats borrow area)	3–7
Cover soil material (Floy Wash borrow area)	1–2
Total	**4–11**

4.1.10 Noise and Vibration

This section addresses the impacts of noise and ground vibration, primarily to human receptors, under the on-site disposal alternative. Where appropriate, impacts to wildlife and cultural resources are also identified. Unless indicated otherwise, all noise and vibration impacts would be temporary and would last only as long as project construction and operations were ongoing.

4.1.10.1 Construction and Operations Impacts at the Moab Site

Noise associated with the on-site disposal alternative would come from construction activities, movement of contaminated soil from the site to the tailings pile, and movement of borrow materials on the site. The largest sources of noise on the site would be heavy earth-moving equipment. Typical noise emissions from construction equipment such as trucks, front-end loaders, bulldozers, excavators, and other heavy equipment range from 70 to 85 dBA at a 50-ft distance (Table 4–5) (Parsons 2003). A combination of the loudest pieces of equipment would have a cumulative noise source of 95 dBA at a 50-ft reference distance. This assumption is conservative, since general operation of equipment would not result in maximum noise levels, and all the equipment would never be at the same point at the same time.

Table 4–5. Noise Levels (dBA) Used for Noise Assessment

Source of Noise	Reference Distance (ft)	Range of Measured Noise Levels (dBA)	Maximum Noise Level Estimate Used (dBA)
Loader	50	82	85
Bulldozer	50	85	85
Backhoe	50	80−82	85
Blade	50	85	85
Roller	50	82	85
Dump Truck	50	79	85
Concrete Truck	50	82	85
Truck at 60 mph	25	81−87	95
Truck at 30 mph	25	77−80	85
Car at 70 mph	25	76−78	80
Car at 35 mph	25	61−65	67
Freight Train	30	72−82	97

A maximum noise level of 95 dBA at 50 ft would produce a 1,480-ft radius of influence where 1-hour L_{eq} noise levels would exceed the noise standard (65 dBA) for the City of Moab (Moab City Ordinance 17.74.080, “Noise Levels”). Moab city limits are approximately 9,840 ft from the tailings pile, well beyond the distance necessary for noise to attenuate to levels below applicable standards. There is one rural residence within 1,480 ft of the site boundary, located adjacent to the northeast portion of the site. This rural residence is on the opposite side of the site from the tailings pile and is more than 1,480 ft from where most of the earth-moving activity would occur.

Surface remediation would not be expected to generate noise levels that would exceed levels associated with earth-moving equipment, and there would be no off-site impact to people. Activities located between the tailings pile and the Colorado River could disrupt wildlife inhabiting the riparian zone along the western shoreline of the Colorado River and recreational users of the river.

Background levels of ground vibration range between 62 and 65 dBV. Ground vibration generated from construction equipment at the Moab site would be estimated to have a maximum level of 95 dBV (Hanson et al. 1991). Levels of ground vibration that approach 92 to 100 dBV could damage fragile buildings. Ground vibration is estimated to follow a logarithmic decrease as distance from the source increases. Vibrations from a 95-dBV source should decrease to levels below human detection within 820 ft. The entrance to Arches National Park is within 820 ft of the Moab site boundary, and visitors could experience small vibrations as a result of activities at the Moab site. Some cultural sites containing rock structures are within 300 to 400 ft of the Moab site boundary, but ground vibration levels are not expected to reach levels (estimated to be 92 to 100 dBV) that would damage these structures at that distance.

4.1.10.2 Impacts from Characterization and Remediation of Vicinity Properties

Remediation of vicinity properties would increase noise levels at the sites as a result of operating excavating equipment, loading trucks for removal, unloading borrow materials at the sites, and performing grading and finishing work. Activities would be limited to usually one piece of heavy equipment (shovel, bulldozer, or grader) and a truck transporting soil to or from the site during daylight hours. People residing on or near the vicinity properties could be disturbed by the noise associated with these activities. A region of influence would extend 820 ft from the remediation site, at which point the modeled noise levels would drop to 65 dBA. These activities would produce a temporary, adverse impact on the properties adjacent to the vicinity properties.

The activities required for remediation of vicinity properties could also produce ground vibration at levels that would disturb nearby residences, but the vibrations would not damage any buildings.

4.1.10.3 Construction and Operations Impacts Related to Transportation

Remediation of vicinity properties would generate noise from trucks used to transport material from the vicinity properties to the Moab site and transport borrow materials from borrow areas to the properties. Many of these trucks would travel through Moab. A total of 30 trips for removal and 30 trips for delivery of borrow material would occur for each of the estimated 98 sites. This would result in a total of 120 truck trips (coming and going) for each of the 98 sites. Remediation of the vicinity properties would last 1 to 3 years, and each site would take 4 to 6 weeks to complete. On average, there would be less than one truck trip per hour, and the contribution above background 1-hour L_{eq} noise levels would be minimal.

In order to haul borrow materials to the Moab site, an upgrade of the existing site entrance from US-191 would be necessary. This construction would employ equipment similar to that used for construction at the Moab site. An estimated maximum noise source of 95 dBA would attenuate to 65 dBA within 1,480 ft. The only receptors potentially located within 1,480 ft of any transportation infrastructure construction would be at Arches National Park. However, the topography and access to Arches National Park make it unlikely that any members of the public would be using the park within 1,480 ft of the construction.

For trucks hauling borrow material to the Moab site (estimated 43 round trips per day), the 1-hour L_{eq} at the construction site would be insignificant compared to the 95-dBA maximum noise level assumed for construction activities. Estimates of noise impacts to areas adjacent to transportation routes for the borrow material are listed in Table 4–6. For all the transportation

Table 4–6. Noise Impacts (1-hour L_{eq}) Around Transportation Routes for Borrow Material

Highway Section	Hourly Average Baseline Noise (dBA) at 25 ft From Source	Hourly Average Project Truck Traffic	Hourly Average Project Truck Traffic Noise (dBA) at 25 ft From Source	Total Noise (dBA) at 25 ft From Source	Increase at 25 ft (dBA) From Truck
Floy Wash to Crescent Junction Exit	74	5.6	66	75	0.7
Crescent Junction to Moab	73	8.3	68	74	1.2
Klondike Flats to Moab	73	8.3	68	74	1.2
Moab[a]	66	1.8	54	66	0.3
La Sal Junction through Moab	73	1.8	61	73	0.3
Spanish Valley through Moab	70	1	59	70	0.3
Lisbon Valley to La Sal Junction	57	1.8	61	63	5.8

Assumptions: Single project truck vehicle noise 95 dBA[b] at 60 mph[a], 25 ft from source.
Single project truck vehicle noise 85 dBA[b] at 60 mph[a], 25 ft from source.
[a]Project truck speed 30 mph within Moab city limits, 60 mph elsewhere.
[b]Conservative estimation based on values from multiple sources (Bowlby 1991, Sandberg 2001)

routes, the impact of additional noise generated by trucks hauling borrow material would be minimal. The distance from US-191 that is modeled to have 1-hour L_{eq} sound pressure level above 65 dBA would increase by 52 ft, from 164 to 216 ft (30 percent increase), by the additional truck traffic. This transportation route goes by Arches National Park and would increase the noise level on a small portion of the park. The National Park has a visitor's center approximately 490 ft from US-191. Noise levels would not be expected to exceed noise standards at the visitor's center or to increase the noise level at the visitor's center by a perceptible amount. The I-70 corridor between Floy Wash and Crescent Junction would be expected to see the largest region of influence, modeled at 243 ft from the roadway.

Transportation of borrow materials through the City of Moab would not be expected to result in a noticeable increase in traffic noise because of the reduced speeds through town and the higher background traffic noise. The route from Lisbon Valley to La Sal Junction would have the greatest impact from trucks hauling borrow material because of the low baseline noise levels. However, the noise levels (1-hour L_{eq}) would not exceed the 65 dBA residential noise standard (Moab City Ordinance 17.74.080, "Noise Levels").

Ground vibration generated by vehicles with rubber tires would be minimal, especially on smooth pavement. Potholes could increase the ground vibration generated by trucks, so vibration within the City of Moab could increase by a small amount. However, ground vibration generated by trucks hauling borrow material would be very near the threshold of human perception at the source.

4.1.10.4 Monitoring and Maintenance Impacts

Monitoring and maintenance of the Moab site would not be expected to result in significant generation of noise. Any noise generated by these activities would attenuate to levels near background before leaving the disposal site boundary.

4.1.10.5 Impacts from All Sources

Noise generated as a result of the on-site disposal alternative would not exceed the City of Moab residential noise standard of 65 dBA at any receptor locations. The receptors with the most potential to notice any increase in noise generated by this alternative would include the resident located on the eastern boundary of the site, residents along SR-46 between Lisbon Valley and La Sal Junction, and visitors at Arches National Park. Ground vibration generated by on-site activities and trucks would be expected to be at or below human perception in most instances.

4.1.11 Visual Resources

This section describes the impacts to physical features of the landscape from activities proposed under the on-site disposal alternative. The impacts would be imposed on viewers who live in, work in, or visit an area and can see ongoing human activities or the results of those activities.

4.1.11.1 Construction and Operations Impacts at the Moab Site

The primary viewers of construction and operations at the Moab site would be southbound and northbound travelers on US-191 and SR-279. Other viewers would include residents of the home immediately northeast of the site, residents of a home at The Portal RV and Park, and a limited number of visitors to Arches National Park. The darkened areas in Figure 4–4 indicate locations from which the disposal cell could potentially be viewed.

The visibility analysis used to create this map is based on elevation and topography and does not take into account the potential obstruction of views from cultural modifications (such as buildings) and vegetation. Consequently, activities at the site would not be viewed from the major portion of the darkened area south and east of the site because of shielding by buildings and tall vegetation (mainly cottonwood trees and tamarisk shrubs).

Travelers southbound on US-191 would be able to view construction activities and the completed disposal cell for approximately 2.5 minutes; viewing time for northbound travelers would be approximately 1.3 minutes. For both northbound and southbound travelers on SR-279, viewing times would be approximately 2.5 minutes. Residents of the home located at The Portal RV and Park generally would not have a clear view of the site or disposal cell when local vegetation is green. The site and cell would become more apparent in winter when the trees and shrubs lose their leaves. Residents at the home immediately northeast of the site would have a clear view of the site year-round. Travelers through Arches National Park would be able to view the site along a 1.2-mile section of the park's access road, from the park entrance to a hairpin turn at the top of the climb; after the turn, the site would not be visible. Construction activities at the site and the completed disposal cell would not dominate the view of the park's visitors, as vehicle drivers would most likely be focused on the park's narrow, winding road, and passengers would likely be viewing the more dramatic features of the park. The primary visual impact on the nearby residents and park visitors would be the dusk and dawn lighting during the construction period.

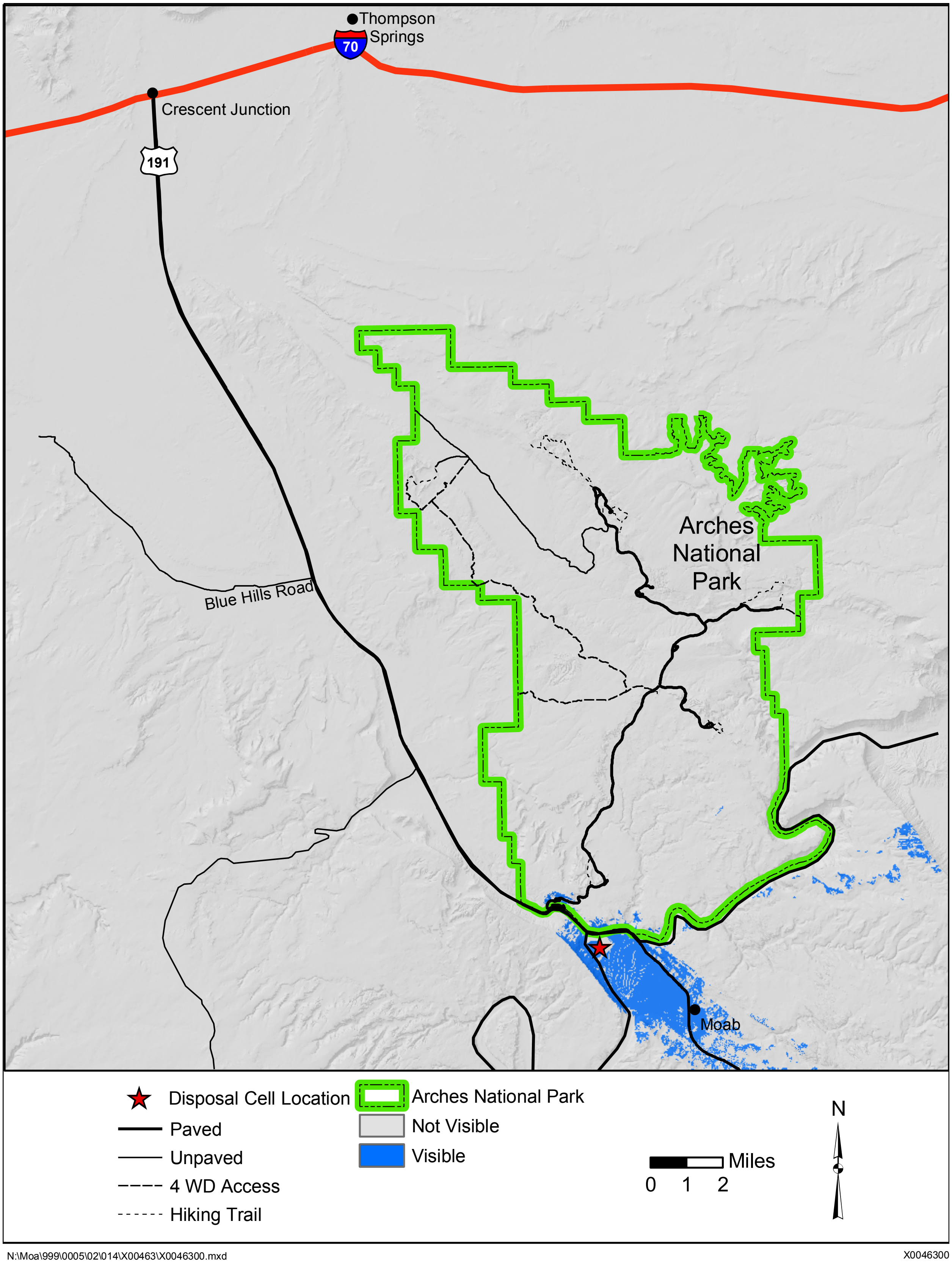

Figure 4–4. Moab Site Visibility Analysis Map

The views of southbound and northbound travelers on US-191 would be the most dramatically affected by this alternative. DOE evaluated visual impacts from three key observation points: (1) along southbound US-191 for a distance of approximately 2 miles, (2) along northbound US-191 for a distance of approximately 1 mile, and (3) along SR-279 for approximately 1.5 miles. At each observation point, DOE assessed the degree and types of changes that would occur in the landscape from the proposed activities (constructing the disposal cell with heavy equipment, covering the side slopes of the current tailings pile with light-gray riprap, filling the riprap interstices with reddish soil, and seeding the entire disposal cell with native or adapted plant species).

During the construction period, the primary visual impacts from the three key observation points would be associated with the dusk and dawn lighting and noticeable movement of heavy equipment on the site. Exhaust emissions and dust generated by the equipment also would be noticeable. In an otherwise natural and still landscape, the lighting, movement, and emissions of the heavy equipment would create moderate contrasts during the day and strong contrasts during dawn, dusk, and nighttime hours. Once the cell was completed, the heavy equipment and on-site lighting would be removed, thus eliminating these impacts in the long term. The short-term adverse visual impacts from construction activities could be minimized by planting a "hedgerow" of trees and shrubs between the disposal cell and US-191 and SR-279. Once the plants matured, they would shield much of the on-site construction activities from travelers during the spring, summer, and fall months.

The strongest contrasts would occur for an approximate 3- to 5-year period after the disposal cell was completed and before vegetation was well established, as shown in the photo simulation in Figure 4–5. In contrast with the natural, complex terrain created by rugged canyon walls, jagged rock formations, and distant mountain peaks, the disposal cell would be characterized by horizontal lines and a simple geometric form. In addition, the pink-stippled, light-gray color of the riprapped side slopes would contrast strongly with the predominant reds and beiges of the natural landscape. The riprap would impart a somewhat rugged texture to the side slopes when viewed close-up. However, from a distance, the side slopes would appear smooth and would create yet another contrast with the surroundings.

Visual Resource Contrast Rating

DOE used BLM's Visual Resource Contrast Rating system (BLM 2003b) to evaluate visual impacts that would occur as a result of the proposed alternatives. From **key observation points**, DOE's visual resource specialist observed the existing landscape at each site proposed to be disturbed under one or more of the alternatives. The basic elements of the landscape—**form, line, color, and texture**—were then compared to the basic elements that would occur as a result of the proposed activity. The degree of contrast that would occur was then rated as **none, weak, moderate, or strong**.

Definitions

Key observation point—one or a series of points on a travel route or at a use area where the view of a proposed activity would be most revealing.

Basic landscape elements—

Form: the mass or shape of an object or group of unified objects, such as the shape of a barren area, a cliff formation, or a pipeline.
Line: the path, real or imagined, that the eye follows when perceiving abrupt differences in form, color, or texture. Within landscapes, lines may be found as ridges, skylines, structures, or changes in vegetation types.
Color: the value, chroma, hue, and reflectivity of an object or area.
Texture: the visual manifestations of the interplay of light and shadow created by the variations in the surface of an object or landscape.

Degrees of contrast—

None: the contrast is not visible or perceived.
Weak: the contrast can be seen but does not attract attention.
Moderate: the contrast begins to attract attention and begins to dominate the landscape.
Strong: the contrast demands attention, will not be overlooked, and is dominant in the landscape.

Figure 4–5. Simulated View of the Moab Disposal Cell from the Southbound Lane of US-191 Immediately After Construction

[Before UDOT widens US-191]

After vegetation was well established, the strong contrasts in line, form, color, and texture would be lessened, as shown in the photo simulation in Figure 4–6. Desert shrubs such as rabbitbrush and fourwing saltbush would be expected to become established on the side slopes and would alter the overall appearance of the cell. Although the dominant form of the cell would remain simple and geometric, the vegetation would soften the harsh horizontal lines and add complexity to the cell's color and texture. Overall, a moderate contrast with the surrounding landscape would be expected.

Neither the strong contrasts anticipated to occur in the short term nor the moderate contrasts anticipated to occur in the long term would be compatible with the Class II objectives (see Section 3.1.15) that BLM has assigned to the nearby landscapes. To meet Class II objectives, the level of change to the existing landscape would have to be low, could not attract the attention of the casual observer, and should repeat the basic elements of line, form, color, and texture that are found in the predominant natural features (BLM 2003). The strong and moderate visual contrasts could be mitigated somewhat by placing beige- and red-colored riprap on the side slopes (instead of light gray); and recontouring the cell to a more complex, less geometric shape. Even then, Class II visual objectives may not be achievable from all viewing locations. DOE is not required to meet the objectives of BLM's visual resource management system on the DOE-owned Moab site; however, the system provides a useful way to measure the effects of a proposed action on visual resources.

Figure 4–6. Simulated View of the Moab Disposal Cell from the Southbound Lane of US-191 After Vegetation Is Established

[Before UDOT widens US-191]

4.1.11.2 Impacts from Characterization and Remediation of Vicinity Properties

Remediation of vicinity properties would result in short-term adverse impacts to visual resources. The removal of vegetation and consequent increase in barren ground would create strong, local contrasts in line, form, texture, and color. The primary viewers of these contrasts would be the residents of the home or facility undergoing remediation and nearby neighbors. Most of the contrasts would be eliminated in the short term, as DOE would replace barren lawn areas with green sod, replace shrubs and trees with nursery-grown plants, and resurface paved areas. No long-term impacts to visual resources would be expected to occur.

4.1.11.3 Construction and Operations Impacts Related to Transportation

Impacts to visual resources would not be expected to occur from transporting vicinity property material or borrow material to the Moab site. Moab residents would notice the presence of large dump trucks and heavy equipment in residential neighborhoods during remediation of vicinity properties, but this impact would be short-term and minor.

4.1.11.4 Monitoring and Maintenance Impacts

Impacts to visual resources would not occur from monitoring and maintenance activities under the on-site disposal alternative.

4.1.11.5 Impacts from All Sources

Stabilizing the tailings pile at its current location on the Moab site would likely have adverse impacts on visual resources. Although the tailings pile would remain in its present location on the Moab site, riprap would be placed on the side slopes, and interstitial voids would be filled with soils and planted with vegetation. From the key observation points established for the site, the predominantly smooth, horizontal lines created by the pile would continue to create a strong contrast with the adjacent vertical sandstone cliffs. Due to its relatively large size, the pile could dominate the view of the casual observer from the US-191 and SR-279 key observation points. It would likely be recognized as an anomalous feature. If light gray riprap were used, it would contrast strongly with the reds of the surrounding cliffs. Unlike the pile in its current condition (covered in red soils), it would likely be noticed by visitors to the Moab area. The visual contrasts that would occur under this alternative would not be compatible with the Class II objectives that BLM has assigned to the nearby landscapes. Although DOE is not required to meet the objectives of BLM's visual resource management system on the DOE-owned Moab site, the system provides a useful way to measure the effects of a proposed action on visual resources. Table 4–7 summarizes the visual resource impacts expected to occur under the on-site disposal alternative. The primary negative impacts would occur in the short term and long term from disposal cell construction.

Table 4–7. Summary of Visual Resource Impacts Under the On-Site Disposal Alternative

Location/Activity	Visual Resource Impacts	
	Short-Term	Long-Term
Moab site	Strong adverse impacts primarily to travelers on US-191 and SR-279	Moderate adverse impacts primarily to travelers on US-191 and SR-279
Klondike Flats borrow area (radon barrier material)	Negligible to no adverse impacts; site not visible to most casual observers	No adverse impacts
Cover soil borrow area	Negligible to strong adverse impacts, depending upon borrow source	No adverse impacts
Vicinity properties	Strong adverse impacts to residents and neighbors	No adverse impacts
Truck haul	Minor adverse impact to residents and neighbors	No adverse impacts
Monitoring and maintenance	No adverse impacts	No adverse impacts

4.1.12 Infrastructure

This section addresses potential impacts on the availability of electric power, potable water, nonpotable water, sewage treatment, rail service, and highways. Unless indicated otherwise, all infrastructure impacts would be temporary and would last only as long as project construction and operations were ongoing.

4.1.12.1 Construction and Operations Impacts at the Moab Site

The primary electrical demands would be associated with the use of the existing mill building as an equipment/vehicle maintenance shop, field office trailer power, security lighting, nighttime operations lighting (if work activities continued into nighttime), river pump stations, and decontamination spray pumps. The electrical service at the Moab site would be required to support an estimated basic demand of 600 kVA. Electric Systems Consultants (ESC) of Fort Collins, Colorado, developed and reviewed this projected demand with Mathew Yates, Pacific

Corporation (Utah Power and Light), Moab, Utah. Pacific Corporation indicated that this demand would present no capacity problems to the existing electrical supply system at the site, nor would system upgrades be required (ESC 2003).

Implementation of this alternative would require an estimated 4,200 gallons of potable water per day to be purchased from the City of Moab. The city potable water system, which is spring-based, currently delivers about 3 million gallons of water per day during the high-demand summer season and about 1 million gallons per day in winter. The city has indicated that the projected 4,200-gallon-per-day demand would not represent a significant impact and could be met without adversely affecting the city's water supply or requiring system upgrades (Swenson 2003).

This alternative would also consume 70 acre-feet of nonpotable water annually (or a project total of approximately 490 acre-feet, assuming a 7-year project duration). All of this water would be drawn from the Colorado River under DOE's existing Moab site water rights, which authorizes DOE to withdraw approximately 3 cfs consumptive use and approximately 3 cfs nonconsumptive use. The authorized total of 6 cfs allows for withdrawal of approximately 4,560 acre-feet per year.

The projected 70 acre-feet per year of total usage is approximately 3 percent of DOE's annual authorized consumptive use withdrawal volume, and less than the 100 acre-feet per year deemed by USF&WS to be protective of endangered fish species. This level of protection complies with the cooperative agreement to implement the "Recovery Implementation Program for Endangered Fish Species in the Upper Colorado River Basin" (USF&WS 1987). Therefore, there would be only a minor impact to designated critical habitat.

Activities at the Moab site would generate approximately 10,000 gallons of sanitary waste per week. The waste would be stored in portable toilets or in septic tanks connected to trailers at the on-site support area. The waste would be disposed of in the City of Moab's sewage treatment plant, which can treat up to 1.5 million gallons of sewage per day and currently treats less than 1 million gallons per day (see Section 3.1.16.1). Consequently, the 10,000-gallons-per-week estimate would represent about 2 percent of the city's current excess treatment volumetric capacity and would not be a significant impact. However, the city restricts the amount of waste it will accept from septic tanks and portable toilets (all sources) to 9,000 gallons per day, and it will only receive such wastes 3 days per week. These restrictions could constrain the amount of waste the city would accept from the Moab site, depending on amounts the city was receiving from other sources. This potential impact could be alleviated by coordinating shipments of the site's sanitary waste so that the restrictions would not be exceeded, or by diluting the waste to a density similar to that of sanitary waste in sewer lines, thereby making disposal acceptable. The city has indicated that it would work with contractors to accommodate disposal schedules and evaluate the applicability of the 9,000-gallon-per-day limit if the waste were diluted. If dilution were necessary, it would represent a relatively small increase in the total nonpotable water use.

4.1.12.2 Impacts from Characterization and Remediation of Vicinity Properties

Under the on-site disposal alternative, activities at the vicinity properties would have no impacts on the local power or rail infrastructure. There would be no impacts on potable or nonpotable water requirements beyond those discussed for activities at the Moab site, which include consumption due to activities at vicinity properties. Not more than one portable toilet should be required for the remediation of any of the vicinity properties. One portable toilet would generate less than 100 gallons of concentrated sanitary waste per week, which should not negatively affect the 9,000-gallon-per-day capacity of the Moab sewage treatment plant for this type of waste.

4.1.12.3 Construction and Operations Impacts Related to Transportation

Transportation of contaminated materials from vicinity properties to the Moab site and transportation of borrow materials from borrow areas to the Moab site would have no impact on the local or regional power, water, or rail infrastructures. Truck traffic transporting vicinity property or borrow area material to the Moab site would result in increased wear and tear on local roads and on US-191. The cost to the state for these impacts would be offset through vehicle registration and special permit fees, both of which provide revenue to the state general highway fund for road maintenance and repair. Transportation plans would include provisions for enforcing speed limits, road load limits, and any other applicable traffic laws.

4.1.12.4 Monitoring and Maintenance Impacts

Monitoring and maintenance activities would be generally limited to periodic inspections and activities to remedy incipient erosion. DOE anticipates that these activities would not impact any element of the local or regional infrastructures.

4.1.12.5 Impacts from All Sources

Power demand of 600 kVA could be met with no impact to Utah Power's existing electric supply infrastructure servicing the site. Potable water demand of 4,200 gallons per day could be met with no adverse impact to the City of Moab's existing potable water supply infrastructure. Nonpotable water demand of 70 acre-feet per year would represent about 3 percent of DOE's existing Colorado River water usage rights at the Moab site. The estimated 10,000 gallons of sanitary waste per week could be treated by the City of Moab's existing sanitary waste treatment infrastructure, but the city's limit of 9,000 gallons per day of concentrated sanitary waste from septic tanks and portable toilets could be exceeded. Mitigation measures to address this potential exceedance would entail coordinating shipment schedules or diluting the waste prior to shipment. Shipments of vicinity property material and borrow materials to the Moab site would result in accelerated wear and tear on neighborhood, county, and state roads. Truck permit and registration fees would compensate the State and Grand County for this unavoidable adverse impact to the road infrastructure.

4.1.13 Solid Waste Management

This section discusses impacts from the generation of solid waste under the on-site disposal alternative. These wastes would be generated for the duration of the remedial action and would cease once remedial action was completed.

4.1.13.1 Construction and Operations Impacts at the Moab Site

Activities at the Moab site would generate approximately 1,040 yd^3 of uncontaminated solid waste per year for 7 to 10 years. This waste would be disposed of at the Grand County landfill, which has a projected lifespan of 64 years at a disposal rate of 30,000 to 35,000 yd^3 per year. The Grand County landfill received approximately 36,000 yd^3 of solid waste in 2002; therefore, the volumes of solid waste generated at the Moab site and disposed of at the landfill would not negatively affect the Grand County landfill's lifespan.

Because the ground water contamination beneath the Moab site includes uranium and radium as well as ammonia and other contaminants (See Section 3.1.6.3), any of the screened ground water treatment technologies discussed in Sections 2.3.2.1 would generate RRM during the estimated 80-year duration of ground water remediation under the on-site alternative. Section 2.3.2.1 discusses possible treatment technologies for the extracted ground water. As noted in Section 2.3.2.1, discharge of ground water to the Colorado River would require extensive treatment and appropriate permits. Either deep well or shallow injection technologies would also require appropriate State and NRC permits. An evaporation treatment technology would require provisions for disposal of the RRM solids that would accumulate in the evaporation ponds. On the basis of dissolved solids content of the ground water, DOE estimates that an evaporation treatment technology would generate approximately 6,600 tons of RRM annually for the 80 years that ground water treatment was ongoing. This waste stream would be disposed of in a properly licensed facility such as a DOE-controlled disposal cell or a commercial disposal facility.

4.1.13.2 Impacts from Characterization and Remediation of Vicinity Properties

Almost all wastes generated at vicinity properties (an average of 300 yd^3 for each vicinity property) would be contaminated material that would be transported to the Moab site for disposal. A very small volume of uncontaminated solid waste could be generated during the remediation of the vicinity properties and would be disposed of directly in the Grand County landfill or in trash receptacles near the vicinity properties. The volume of solid waste generated during the remediation of each vicinity property would be variable but would not negatively affect the Grand County landfill's lifespan.

4.1.13.3 Construction and Operations Impacts Related to Transportation

Small volumes of uncontaminated solid waste could be generated during transportation of contaminated materials from vicinity properties to the Moab site and during transportation of borrow materials to the Moab site. These wastes would be disposed of in the Grand County landfill.

4.1.13.4 Monitoring and Maintenance Impacts

Very small volumes of waste would be generated as a result of ongoing inspections and monitoring. All wastes would be managed in accordance with applicable laws and regulations.

4.1.13.5 Impacts from All Sources

Management of an estimated 1,040 yd^3 of uncontaminated solid wastes generated as a result of activities at the site for 7 to 10 years would not result in adverse environmental or waste disposal capacity impacts. About 6,600 tons of RRM would be generated annually for 80 years if an evaporation-based ground water remediation treatment were implemented. These wastes would be handled, recycled, or disposed of according to approved waste management plans and applicable state and federal regulations.

4.1.14 Socioeconomics

This section discusses the potential socioeconomic impacts under the on-site disposal alternative. Project activities would be executed over three phases: a pre-remediation phase, a remediation phase, and a post-remediation phase. The potential impacts are examined using geographically and industrially detailed information on expected direct and indirect changes in output, earnings, and employment over the construction and transportation phases of the project. The analysis also considers potential impacts from increased demand for temporary housing, and the short-term and long-term influence of surface remediation on the regional tax base and future economic development opportunities.

The affected socioeconomic region of influence covers Grand County and San Juan County in southwestern Utah. The impact analysis uses annualized project cost information specific to actions undertaken for the on-site disposal alternative developed from DOE's cost estimates for each alternative. This information is summarized for all on-site and off-site disposal alternatives in Table 4–8.

Data sources used for these estimates include:

- Actual vendor quotes
- RS Means 2003 Cost Estimating Guides (RS Means 2003)
  —Environmental Remediation Cost Data—Unit Pricing, 9th Edition
  —Environmental Remediation Cost Data—Assemblies, 9th Edition
  —Site Work & Landscape Cost Data, 22nd Edition
  —Building Construction Cost Data, 61st Edition
  —Heavy Construction Cost Data, 17th Edition
- Similar project experience

The cost information provided in Table 4–8 itemizes the total project costs by alternative that were summarized in Table 2–35 and includes cost for:

A. The pre-remediation phase during which design, procurement, and site preparation would occur.
B. The remediation phase of the project during which surface and ground water remediation would occur.
C. A 10-percent cost-contingency on these two phases.
D. Annual surface remediation costs assuming an 8-year duration.
E. Annual ground water remediation costs that would be incurred for 80 years under on-site disposal and 75 years for the off-site disposal alternatives and annual post-surface remediation costs.
F. Total annual costs for each alternative during active surface and ground water remediation assuming an 8-year duration.

Table 4–8. Remediation Costs

	(A) Total Pre-Remediation Phase	(B) Total Remediation Phase	(C) 10-Percent Contingency (A and B)	(D) Annual Surface Remediation Costs (8-year period)	(D) Annual Ground Water and Post-Remediation Costs (75–80 years)	(E) Annual Total Cost (8-year period)
On-Site Disposal						
Moab site	$8,170,000	$142,660,000	$15,083,000	$165,913,000.00	$942,000	$20.7 million **$20,739,125 (calculated)**
Off-Site Disposal						
Klondike Flats Truck	$8,170,000	$292,106,000	$30,027,600	$330,303,600.00	$933,000	$41.3 million **$41,287,950 (calculated)**
Rail	$8,170,000	$348,037,000	$35,620,700	$391,827,700.00	$933,000	$49 million **$48,978,463 (calculated)**
Pipeline	$10,982,000	$348,303,000	$35,928,500	$395,213,500.00	$933,000	$49.4 million **$49,401,688 (calculated)**
Crescent Junction Truck	$8,170,000	$295,404,000	$30,357,400	$333,931,400.00	$933,000	$41.9 million **$41,858,125 (calculated)**
Rail	$8,170,000	$351,272,000	$35,944,200	$395,386,200.00	$933,000	$49.5 million **$49,539,975 (calculated)**
Pipeline	$12,187,000	$353,330,000	$36,551,700	$402,068,700.00	$933,000	$50.4 million **$50,375,288 (calculated)**
White Mesa Mill Truck	$8,170,000	$373,812,000	$38,198,200	$420,180,200.00	$933,000	$52.6 million **$52,639,225 (calculated)**
Pipeline	$13,257,000	$410,197,000	$42,345,400	$465,799,400.00	$933,000	$58.3 million **$58,341,625 (calculated)**

On the basis of the above cost information, economic impacts for the Moab remediation project were estimated using the Regional Input-Output Modeling System II (RIMS II) method of the Bureau of Economic Analysis, U.S. Department of Commerce (BEA 1997). This methodology is widely used in systematic analysis of economic impacts from large-scale public sector projects. The RIMS II method takes account of interindustry relationships within the two-county socioeconomic region of influence, which largely determine how the regional economy would respond to the infusion of new spending resulting from construction-transportation activities undertaken in the Moab site remediation.

The RIMS II multipliers used in the analysis were estimated by the Bureau of Economic Analysis specifically for Utah's Grand and San Juan counties. Final-demand and direct-effect multipliers for the construction sector are used in estimating the impact of the Moab surface remediation project on regional output, earnings, and employment. The impact on annual output of goods and services and labor earnings is calculated as the products of the final-demand multipliers (1.3178 and 0.3250) and annualized project cost. The impact on annual labor employment is calculated as the product of the direct-effect multiplier (1.4262) and estimated direct employment for each action alternative. Table 4–9 reports the associated economic impacts along with annual project costs.

Table 4–9. Economic Impacts in the Two-County Socioeconomic Region of Influence

On-Site Disposal[a]	Annual Cost	Annual Output of Goods and Services	Annual Labor Earnings	Jobs
Moab Site	$20,739,125	$27,330,019	$6,740,216	171

[a]Economic impacts for regional output of goods and services and labor earnings are calculated based on final-demand multipliers provided by the Bureau of Economic Analysis. The respective multiplier values (1.3178 and 0.3250) are multiplied by annualized cost to generate the impact values shown. Employment impacts are calculated as the product of the direct-effects multiplier (1.4262) and 120 total direct jobs (see Table 2–4).

The industries expected to be initially affected by the project include the regional construction and transportation industries, along with supporting service industries (especially hotels and restaurants). The project workforce is assumed to come from outside the socioeconomic region of influence and to spend a portion of their earnings on housing, food, and other goods and services within the two-county socioeconomic region of influence.

These impacts are based on estimated annual project costs of $20,739,125 over an 8-year disposal period, followed by estimated annual costs of $942,000 over an additional 80-year period of ground water remediation/site monitoring. These annual expenditures would cover the various activities described above, including construction and operations at the Moab site; ground water remediation; characterization and remediation of vicinity properties; transportation of vicinity property materials and borrow materials to the Moab site; and monitoring and maintenance impacts. Over the 8-year disposal period, the annual expenditures reflect increased annual output of goods and services of $27,330,019; increased annual labor earnings of $6,740,216; and increased direct and indirect employment of 171. Annual ground water remediation and site monitoring expenditures over the 80-year period following completion of surface remediation would not have significant impacts on the output of goods and services, labor earnings, or employment levels in the two-county region.

The potential shorter-term impacts from the on-site disposal alternative include effects on the demand for temporary housing. Project workers would take up temporary housing in the two-county socioeconomic region of influence, and their spending on goods and services would result in the collection of tax revenues by the state. As noted in Section 3.1.18.2, the availability of temporary housing is heavily dependent on tourist-recreation activity. The remediation project would tend to cause some crowding-out impacts during the peak tourism season due to increased competition for temporary accommodations. However, lower vacancy rates would be expected during the off-season, as workers took up temporary accommodation in the two counties. The increase in the workforce would tend to last over the duration of the surface remediation project. Consequently, any potential impacts on public safety (police, fire, medical) or on local school systems would be restricted to the duration of the project.

Longer-term beneficial impacts from the on-site disposal alternative relate to greater opportunities for economic development in the Moab area and greater diversification of the tax base. Currently, the local tax base depends heavily on the seasonally driven tourist-recreation sector. New spending and tax collections during and after the remediation process would help diversify the current tourist-driven tax base. These longer-term impacts would depend upon continued growth in the recreational demand for land and water resources in the socioeconomic region of influence, particularly in the vicinity of the Moab site and vicinity properties. The remediation process would improve both land and water quality in these areas and would safeguard surface and ground water quality for future beneficial uses along the Colorado River, such as rafting and camping.

4.1.15 Human Health

This section addresses potential impacts to human health under the on-site disposal alternative. These impacts include the potential for worker deaths that could occur as a result of industrial accidents, worker or public latent cancer fatalities that could occur as a result of exposure to radiation from activities at the Moab site, at vicinity properties, or during transportation of materials to the Moab site. In addition, residents would be exposed to radon gas and radioactive particulates released from the Moab site.

4.1.15.1 Construction and Operations Impacts at the Moab Site

Under the on-site disposal alternative, construction activities at the Moab site would be estimated to result in less than one fatality (0.16) as a result of industrial accidents.

During operations, workers at the site would be exposed to radon gas (an inhalation hazard) and external radiation from the mill tailings at the site. According to monitoring data collected during construction of an evaporation pond on the tailings pile, the highest radon level measured on the pile was 0.096 working levels (21 pCi/L). A worker exposed to this level of radon for 2,000 hours per year has a latent cancer fatality risk of 6.1×10^{-4} per year of exposure. The highest external gamma exposure rate measured on the tailings pile was about 0.60 milliroentgen per hour (mR/h). A worker exposed to this level of radiation for 2,000 hours per year would have a latent cancer fatality risk of 6.0×10^{-4} per year of exposure. The total latent cancer fatality risk to the worker on the tailings pile would be 1.2×10^{-3} per year of exposure (Table 4–10), or 6.0×10^{-3} over the 5-year duration of activities at the Moab site.

Table 4–10. Worker Impacts for the On-Site Disposal Alternative (Moab Site)

Category of Worker	Radon-Related LCFs[a]	External Radiation-Related LCFs[a]	Total LCFs[a]
Annual			
Individual	6.1×10^{-4}	6.0×10^{-4}	1.2×10^{-3}
Population	0.029	0.028	0.057
5-Year Duration of Activities			
Individual	3.0×10^{-3}	3.0×10^{-3}	6.0×10^{-3}
Population	0.14	0.14	0.28

[a]LCF = latent cancer fatality based on 47 workers at the Moab site.

Remediation at the Moab site would employ about 47 workers. If they were all exposed to radon and external radiation at the levels discussed for individual workers, the latent cancer fatality risk for this population of workers would be 0.057 per year of exposure, or 0.28 over the 5-year duration of surface remediation activities at the Moab site.

For non-workers (i.e., local residents), monitoring data collected during 2002 and 2003 around the Moab site indicate that the radon concentration at the location of the maximally exposed individual is about 1.9 pCi/L. Assuming that this individual was exposed for 8,760 hours per year, this would be equivalent to a latent cancer fatality risk of 1.2×10^{-3} over the 5-year duration of activities for the on-site disposal alternative.

Monitoring data collected during 2002 and 2003 indicate that the latent cancer fatality risk to the maximally exposed individual from radioactive particulates would be about 4×10^{-6} over the 5-year duration of activities for the on-site disposal alternative.

For the population, over the 5 years of activity at the Moab site, the latent cancer fatality risk from radon releases to the population surrounding Moab would be 0.080.

As described under the proposed action for ground water remediation (Section 2.3.2), a 40-acre evaporation pond could be constructed to treat extracted ground water. The water pumped to this pond would be contaminated with ammonia at concentrations of about 1,000 mg/L. The atmospheric concentration of this ammonia for a nearby resident was estimated to be about 2.1 mg/m^3. This concentration is less than the Temporary Emergency Exposure Limit-0 (TEEL-0) value of 15 mg/m^3 for ammonia, which is the threshold concentration below which most people experience no adverse health effects.

4.1.15.2 Impacts from Characterization and Remediation of Vicinity Properties

Remediation at vicinity properties would be estimated to result in less than one fatality (0.031) as a result of industrial accidents.

Radiation exposure at the vicinity properties has not been extensively characterized. However, on the basis of data from other vicinity properties (DOE 1985), the indoor radon level at vicinity properties was estimated to be about 0.046 working levels (7 pCi/L), and the external gamma exposure rate at vicinity properties was estimated to be 0.12 mR/h. A worker exposed for 2,000 hours per year would have a latent cancer fatality risk of 2.9×10^{-4} for radon and 1.2×10^{-4} for external radiation. The total latent cancer fatality risk for a worker at vicinity properties would be 4.1×10^{-4} per year of exposure (Table 4–11), or 1.2×10^{-3} over the 3-year duration of activities at the vicinity properties.

Table 4–11. Worker Impacts for the On-Site Disposal Alternative (Vicinity Properties)

Category of Worker	Radon-Related LCFs[a]	External Radiation-Related LCFs[a]	Total LCFs[a]
Annual			
Individual	2.9×10^{-4}	1.2×10^{-4}	4.1×10^{-4}
Population	6.7×10^{-3}	2.9×10^{-3}	9.6×10^{-3}
Duration of Activities			
Individual	8.7×10^{-4}	3.7×10^{-4}	1.2×10^{-3}
Population	0.020	8.6×10^{-3}	0.029

[a]Based on 23 workers at vicinity property sites.

About 23 workers would be employed at the vicinity properties. If they were all exposed to radon and external radiation at the levels discussed for individual workers, the latent cancer fatality risk for this population of workers would be 9.6×10^{-3} per year of exposure, or 0.029 over the 3-year duration of activities at the vicinity properties.

Prior to remediation activities, people living at the vicinity properties would be exposed to radon and external gamma radiation levels similar to those mentioned previously—indoor radon levels of about 0.046 working levels (7 pCi/L) and external gamma exposure rate of about 120 microroentgens per hour (μR/h). A person exposed for 8,760 hours per year would have a latent cancer fatality risk of 1.3×10^{-3} for radon and 6.5×10^{-4} for external gamma radiation. The total latent cancer fatality risk for a person at vicinity properties prior to remediation would be 1.9×10^{-3} per year of exposure, or 9.6×10^{-3} if this individual lived at a vicinity property for 5 years prior to remediation. If four people lived at each of the 98 vicinity properties, the latent cancer fatality risk for these 392 people would be 0.76 per year of exposure. If these people lived in the vicinity properties for 5 years, about 4 (3.8) of them would die from cancer caused by the mill tailings contamination.

Remediation of the vicinity properties would reduce the radon and external radiation levels at those properties to levels specified by EPA standards, 0.02 working levels (about 3 pCi/L) for radon and 20 μR/h for external gamma exposure rate. A person exposed for 8,760 hours per year would have a latent cancer fatality risk of 5.5×10^{-4} for radon and 1.1×10^{-4} for external gamma radiation. The total latent cancer fatality risk for a person at vicinity properties would be 6.6×10^{-4} per year of exposure. If four people lived at each of the 98 vicinity properties, the annual latent cancer fatality risk for all of these people combined would be 0.26. Over the 30-year post-remediation time period, about 8 (7.8) of these people would die from cancer. Over the entire 35-year pre- and post-remediation time period, about 12 of these people would die from cancer.

4.1.15.3 Construction and Operations Impacts Related to Transportation

The on-site disposal alternative would require about 2,940 shipments of contaminated materials from vicinity properties to the Moab site and 56,463 shipments of borrow material to the Moab site. The borrow material would consist of cover soils, radon and infiltration barrier soils, sand and gravel, riprap, and Moab site reclamation soils.

The transportation impacts of shipping contaminated materials from vicinity properties and borrow material would be from two sources: radiological impacts and nonradiological impacts. Radiological impacts would be from incident-free transportation and from transportation accidents that released contaminated material. There would be no radiological impacts from moving borrow material because it is not contaminated. Nonradiological impacts would be from engine pollution (emissions from the trucks moving the contaminated material and the borrow material) and from traffic fatalities. The total transportation impacts would be the sum of the radiological and nonradiological impacts. Additional details on these analyses are provided in Appendix H.

Table 4–12 lists the transportation impacts for the on-site disposal alternative. For this alternative, DOE estimates there would be less than one fatality. In comparison, about 40,000 traffic fatalities occur annually in the United States (U.S. Census Bureau 2000) and about 335 occur annually in Utah (DOT 2004).

Table 4–12. Transportation Impacts for the On-Site Disposal Alternative

Alternative	Radiological			Nonradiological		Total Fatalities
	Incident-Free		Accident Risk LCFs	Pollution Health Effects Fatalities	Traffic Fatalities	
	Public LCFs	Worker LCFs				
Vicinity properties	2.7×10^{-5}	3.9×10^{-5}	6.9×10^{-9}	3.7×10^{-4}	1.1×10^{-3}	1.5×10^{-3}
Borrow material	0	0	0	1.1×10^{-3}	0.081	0.082
Mill tailings	0	0	0	0	0	0
Total	$\mathbf{2.7 \times 10^{-5}}$	$\mathbf{3.9 \times 10^{-5}}$	$\mathbf{6.9 \times 10^{-9}}$	$\mathbf{1.5 \times 10^{-3}}$	**0.082**	**0.084**

LCF = latent cancer fatality.

Workers. For truck shipments of mill tailings from vicinity properties to the Moab site, the maximally exposed transportation worker would be the truck driver. This person would receive a radiation dose of 26 mrem/yr, which is equivalent to a probability of a latent cancer fatality of about 1.3×10^{-5}.

Public. For truck shipments of mill tailings from vicinity properties to the Moab site, the maximally exposed member of the public would be a person who happened to be in a traffic jam next to a truck containing mill tailings. This person would receive a radiation dose of 0.084 mrem, which is equivalent to a probability of a latent cancer fatality of about 5.0×10^{-8}.

Accidents. The maximally exposed individual member of the public would receive a radiation dose of 0.048 mrem or 4.8×10^{-5} rem from the maximum dose reasonably foreseeable in a transportation accident involving a shipment of mill tailings from a vicinity property to the Moab site. This is equivalent to a probability of a latent cancer fatality of about 2.9×10^{-8}. The probability of this accident is about 4×10^{-4} per year. The population would receive a collective radiation dose of 5.6×10^{-4} person-rem from this accident. This is equivalent to a probability of a latent cancer fatality of about 3.3×10^{-7}.

4.1.15.4 Monitoring and Maintenance Impacts

Monitoring and maintenance activities would include checking water quality, installing a long-term ground water monitoring system, and conducting periodic maintenance and inspections of the site (checking for erosion, damaged fencing, etc.). None of these activities would be expected to breach the cap over the tailings; the installation of the ground water system would be done in clean areas after remediation was complete. Data from another UMTRCA site indicate that the on-site disposal alternative would be effective in isolating contaminants in the tailings from individuals conducting activities on the site. DOE (2001) concluded that both radon and gamma levels associated with the capped-in-place tailings pile at the Shiprock site in New Mexico were indistinguishable from naturally occurring radiation levels. Therefore, the risk to workers conducting monitoring and maintenance would be comparable to the latent cancer fatality risk from background levels of radioactivity in Utah, about 3×10^{-4} per year of exposure.

4.1.15.5 Impacts from All Sources

Under the on-site disposal alternative, construction activities would occur at vicinity properties, borrow areas, and at the Moab site. Table 4–13 lists the construction-related impacts (fatalities) from these activities. For this alternative, less than one fatality would be estimated to occur from all construction activities.

Table 4–13. Construction-Related Fatalities for the On-Site Disposal Alternative

Alternative	Construction Fatalities
Truck option	
Vicinity properties	0.031
Borrow areas	0.014
Moab site activities	0.11
Total	**0.16**

Table 4–14 shows the total impacts that could occur to workers as a result of exposure to radiation during activities at the Moab site and at vicinity properties.

Table 4–14. Worker Impacts for the On-Site Disposal Alternative (Moab Site and Vicinity Properties)

Category of Worker	Site	Radon-Related LCFs	External Radiation-Related LCFs	Total LCFs[a,b]
Annual				
Individual	Moab	6.1×10^{-4}	6.0×10^{-4}	1.2×10^{-3}
	Vicinity properties	2.9×10^{-4}	1.2×10^{-4}	4.1×10^{-4}
Population	Moab	0.029	0.028	0.057
	Vicinity properties	6.7×10^{-3}	2.9×10^{-3}	9.6×10^{-3}
Total		**0.036**	**0.031**	**0.067**
5-Year Duration of Activities				
Individual	Moab	3.0×10^{-3}	3.0×10^{-3}	6.0×10^{-3}
	Vicinity properties	8.7×10^{-4}	3.7×10^{-4}	1.2×10^{-3}
Population	Moab	0.14	0.14	0.28
	Vicinity properties	0.020	8.6×10^{-3}	0.029
Total		**0.16**	**0.15**	**0.31**

[a]Based on 47 workers at the Moab site.
[b]Based on 23 workers at vicinity property sites.

Based on as-built radon flux measurements from completed uranium mill tailings disposal cells constructed under both Title I (federal UMTRA Project sites) and Title II (private licensees) of UMTRCA, it is anticipated that actual radon flux would be two orders of magnitude less than the 20-pCi/m^2-s EPA protective standard promulgated in 40 CFR 192. Consequently, it is not expected that radon release from the capped pile would be a contributing source to future exposures. Table 4–15 presents the risks that would occur from residual on-site contamination (ground water) to a future resident, rafter, and camper on the Moab site. In all cases, added cancer risk would be less than a one-in-one-million probability of developing cancer. The potential for noncarcinogenic impacts would be less than the benchmark (a hazard index of 1). The detailed assumptions and calculation methods used to estimate these risk are presented in Appendix D.

Even though DOE's experience supports a conclusion that radon release rates from the capped pile would be negligible and that DOE's long-term monitoring and maintenance of the site would ensure cap integrity, for the purpose of supporting analyses of long-term performance and impacts, DOE has also assessed impacts assuming the maximum allowable release rate of radon, 20 pCi/m^2-s, under EPA's regulations (40 CFR 192). On the basis of this emission rate and the dimensions of the tailings pile, the latent cancer fatality risk for a nearby resident of Moab would be 8.9×10^{-5} per year of exposure, or 2.7×10^{-3} over the 30-year period following the end of construction and operations. This latent cancer fatality risk is less than the risk from background levels of radioactivity in Utah, about 3×10^{-4} per year of exposure or 0.9×10^{-2} over 30 years. Stated differently, the incremental additional latent cancer fatality risk from the maximum permissible disposal cell radon flux to the nearest individual, which is likely orders of magnitude greater than realistic future emission rates, is roughly one-third of the risk from natural background conditions to an individual in the state of Utah. The calculation methods used to estimate these risk are also presented in Appendix D.

Similarly, the annual latent cancer fatality risk for the population within a 50-mile radius of the site was estimated to be 6×10^{-3}. For this same population, the latent cancer fatality risk from the maximum permissible disposal cell radon flux would be 0.18 over the 30-year period following the end of construction and operations. These calculations are based on a distributed population size of 11,028.

The design life of the disposal cell for the uranium mill tailings is 200 to 1,000 years. Over this period of time, the amount of radioactivity in the disposal cell will decrease slightly, less than 1 percent, due to the half lives of the radionuclides contained in the uranium mill tailings. In the time frame of 200 to 1,000 years, the major route of exposure of people would be through the inhalation of radon progeny from the disposal cell. The ground water at the Moab site is naturally high in salts and would not be used for human consumption. Releases of radionuclides to surface water would be diluted by the flow of the Colorado River. Consequently, it is unlikely that ground water and surface water would contribute large latent cancer fatality risks relative to inhalation of radon progeny. With the disposal cell cover in place and the Moab site being under perpetual care, it is likely that the latent cancer fatality risk for an inadvertent intruder would also be low.

Table 4–15. Future Potential Risks for the On-Site Disposal Alternative

Overall Summary for All Receptors and Pathways[a]							
	Added Cancer (Unitless Probability)				**Noncarcinogenic Risks (HI)[b]**		**Notes**
	Chemical		**Radionuclides**				
Receptor	**CT[b]**	**RME[b]**	**CT**	**RME**	**CT**	**RME**	
Resident							Assumes clean, municipal source of domestic water
Adult	0.00	0.00	NA	NA	0.00	0.00	Assumes clean fill at the site from borrow areas
Child	0.00	0.00			0.00	0.00	
Rafter							Assumes 1 day of exposure per year
Child	7.5×10^{-10}	9.38×10^{-10}	1.38×10^{-9}	1.72×10^{-9}	0.00	0.00	Exposure would be from child play in surface water contaminated by ground water
Camper							Assumes 1 day of exposure per year
Adult	6.53×10^{-9}	8.16×10^{-7}	3.86×10^{-8}	6.88×10^{-8}	0.02	0.03	Clean soil in areas of exposure
Child	1.10×10^{-8}	2.47×10^{-8}	2.04×10^{-8}	4.44×10^{-8}	0.02	0.04	Exposure would be from child play in surface water contaminated by ground water
Outside Worker							Assumes clean, municipal source of domestic water
Adult	1.36×10^{-8}	1.01×10^{-7}	NA	NA	0.00	0.01	

Note: Under the on-site disposal alternative, contaminated surface material would be placed in an engineered disposal cell (the ground water would still be contaminated). The contaminated surface materials would be isolated in the on-site cell. No dose from these isolated materials would be expected.
[a] See Appendix D for details on the assumptions and calculation methods used to estimate the risks.
[b] HI = Hazard Index; CT = Central Tendency: RME = Reasonable Maximum Exposure.

As with the radioactivity in the disposal cell, the annual risk would also not decrease appreciably over the 200- to 1,000-year time. Therefore, the annual latent cancer fatality risk for a nearby Moab resident would be about the same immediately after the cover is installed as it would be 1,000 years after the cover is installed, about 8.9×10^{-5} per year of exposure. Based on the 20-pCi/m^2-s radon release rate, for the population within a 50-mile radius of the site, the estimated annual latent cancer fatality risk would be 6×10^{-3}. As with the radioactivity in the disposal cell, the annual population risk would also not decrease appreciably over the 200- to 1,000-year time frame. If it is assumed that the population around the Moab site remains constant over 1,000 years, then an estimated 6 latent cancer fatalities over the 1,000-year time period would occur.

4.1.16 Traffic

This section summarizes potential impacts to traffic in the area affected by the on-site disposal alternative. In the following discussions, estimated percent increases in traffic are based on increases over the 2001 AADT for all vehicles or for trucks on segments of US-191 or I-70 (see Table 3–15). Implementation of this alternative would increase area traffic due to construction and operations at the Moab site, remediation of vicinity properties, and transport of borrow materials from borrow areas to the Moab site and vicinity properties. There would be initial unknown but minor short-term (period of several months) increases in area traffic on US-191 while various site preparations took place. These activities would include bringing heavy construction equipment to the site, such as backhoes, graders, front-end loaders, bulldozers, and trucks; constructing secure stockpile areas for various materials to be used during the remedial action (e.g., diesel fuel, water for dust control); and bringing a variety of construction trades to the site to set up temporary field offices and prepare road access areas. These activities would add to area traffic and could result in minor congestion and inconveniences near the site entrance on US-191.

Workers would commute to the Moab site for jobs at the site, at vicinity properties, and at borrow areas. DOE estimates that the average annual vehicle trips associated with these workers could increase daily traffic in central Moab by an estimated 240 vehicle trips per day on US-191. Although the addition of 240 vehicle trips per day would result in only a 1-percent increase in daily traffic (the reported 2001 AADT in central Moab was 16,045 vehicles of all types), UDOT reports the current traffic situation in Moab as highly congested. Thus, these additional vehicle trips would exacerbate the current congestion problem. Miscellaneous trips for supplies and meals would also add to traffic congestion. However, the above estimate is based on a worst-case analysis that assumes that all 120 workers (see Table 2−4) would need to traverse central Moab to access the Moab site. It is more likely that some workers, possibly one-half of the work force, would come from cities north of Moab, such as Green River, Utah, or Grand Junction, Colorado, and that some workers would car-pool. Also, these trips would occur before 7:00 a.m. and after 7:30 p.m., which are times of the day when traffic volumes would be lower.

Trucks carrying borrow material would travel from borrow sources north (cover, radon barrier, and reclamation soils) and south (sand, gravel, and riprap) of the Moab site, and all of these trips would occur on segments of US-191. North of the Moab site, average annual daily truck traffic on US-191 would increase by 70 daily trips (calculated from Table 2–2). Average annual daily truck trips would increase from 857 to 927, or approximately an 8 percent increase over 2001 levels. Because the destination of these trucks would be the Moab site, they would not pass through the City of Moab. An estimated 16 truck trips per day would be required to provide sand, gravel, and riprap from sources south of the Moab site. This increase would not be expected to affect traffic on US-191 south of Moab, but because these trucks would have to pass through Moab they would add to the traffic congestion on US-191 in central Moab.

Trucks carrying vicinity property material to the Moab site (and transporting backfill to the properties) would use US-191 both north and south of Moab (Figure 2–7) and also local roads or streets. The estimated maximum of 48 daily one-way trips hauling this material would increase the average annual truck traffic on US-191 by 6 percent. Many of these trips would traverse all or part of Moab.

Monitoring and maintenance activities at the site would result in fewer than five vehicles per day and would be inconsequential compared to existing traffic volumes.

4.1.17 Disposal Cell Failure from Natural Phenomena

This section addresses the potential natural processes that could cause a failure of the disposal cell at the Moab site and the expected consequences and potential risks. The focus of this analysis is to evaluate the potential consequences of contaminants in the water and sediments of the Colorado River based on a significant (catastrophic) release of tailings. Although the probability of a significant release would be very small over the design life of the on-site disposal cell, this type of failure was assumed to occur in order to evaluate the potential consequences (risks).

Several processes could affect the integrity of the disposal cell at the Moab site:

- *Flooding*—Over the design life of the disposal cell (200 to 1,000 years), severe flooding of the Colorado River and of the Moab Wash drainage could occur from a large precipitation event in the Moab area and upstream of the Moab area or a failure of a dam on an upstream tributary of the Colorado River.
- *River Migration*—The Colorado River could migrate into the disposal cell over an extended period of time. Because this river migration would be assumed to occur over many years, a failure of long-term management of the pile would also have to occur for tailings releases to be significant.
- *Seismic Activity/Basin Settling*—Although seismic activity is unlikely (see Section 3.1.1.4), the Moab site sits on salt beds that are prone to dissolution over extended periods of time. Dissolution of the salt beds could cause differential settling and disrupt the integrity of the disposal cell. Settling of the entire cell would tend to increase the possibility of impacts from floods or river migration and would tend to increase the potential for ground water contamination.
- *Cap Erosion/Failure*—During major storms or basin settling, it is possible that some failure or breach of the tailings pile cap or cover could occur. This would result in a slow release of contamination to the river and would include the possibility of increased radon releases.

Two types of failures could occur: catastrophic and long-term. A catastrophic failure could occur during a major flood or a seismic event. A long-term, slow release would be possible for events such as river migration, basin settling, or intermittent erosion of the cell cover. Long-term failures assume smaller-quantity releases over an extended period (many years); a continuation of this type of release would also require a failure of long-term management (this assumes that no repairs to the damaged cell would be done). This type of release, which is possible at all UMTRCA Title I sites, can be mitigated. DOE's newly created (2003) Office of Legacy Management is responsible for monitoring and mitigating this type of release. The hypothetical catastrophic failure could release a large quantity of tailings into a relatively small volume of water compared to long-term releases, which would release a small quantity of tailings into a large volume of water (river flow over many years). Consequently, the assumptions associated with the hypothetical catastrophic event would yield the worst-case situation (more tailings released and higher contaminant concentrations in water).

Risks to humans would be based on some type of activity that would bring people in contact with contamination. In this case, the contamination currently in the tailings pile was assumed to be dispersed downstream during an event such as a flood, and it was assumed that people would come in contact with this contamination in the water or sediments. Exposure of humans to the contamination would depend on what people were doing in the contaminated area. Examples could include building a house and living in this area, camping, or river rafting. These events result in differing time periods that people could spend in contaminated areas and differing activities that could cause someone to be exposed to the contamination (e.g., drinking contaminated water, breathing contaminated air). Risks increase with increasing time and exposure to contamination. Situations where people were exposed to contaminated media (soil, sediments, water, air) for a long period (many hours per day for many years) would yield the highest risks for the same level of contamination in the contaminated media. Other activities such as camping in a contaminated area would yield lower risks because exposure to contamination would occur for a limited number of days per year.

Two types of scenarios were analyzed. First, it was assumed that someone would build a house on contaminated sediments released from the tailings pile at a location downstream of the pile (residential scenario). This scenario assumes a home would be built in a contaminated area and the contaminated water (in this case, contaminated surface water) would be used as the primary drinking water source for many years (in reality, the contaminant concentrations in water would only last on the order of days; therefore, the exposures to contaminated water under a residential scenario are unrealistically high but provide an upper bound to the potential risks). The most significant risks would occur from ingestion of contaminated drinking water and exposure to the radon in air originating from radium-226. This assumes that a flood deposited contaminated sediments in an area where it was feasible to construct a house (e.g., outside the 100-year floodplain).

Second, it was assumed someone would camp in a contaminated area downstream of the pile (camping scenario). The camping scenario assumes two overnight camping events per year in contaminated areas and the accidental ingestion of contaminated surface water and sediments. This scenario was assumed because it yields more worst-case risks than those estimated using assumptions for rafting (the other likely recreational use of the area downstream of the Moab site).

Table 4–16 presents the estimated maximum level of contaminants in water and sediment that would still be protective of human (and ecological) health. The basis for these levels is provided in Appendix D.

Table 4–16. Maximum Exposure Level of Contaminants Protective of Human Health and Ecological Resources

Medium/ Contaminant	Maximum Exposure Level Protective of Human Health (Residential Scenario)[a]	Maximum Exposure Level Protective of Human Health (Camping Scenario)[a]	Maximum Exposure Level Protective of Ecological Resources (Aquatic)[a]	Maximum Exposure Level Protective of Ecological Resources (Terrestrial)[a,b]
Water/uranium	0.11 mg/L	19−36 mg/L	0.0026−0.455 mg/L 1.3 mg/L (chronic) 2.1 mg/L (acute)	7.00−68.8 mg/L
Water/ammonia-N	0.21 mg/L	NA	Approx. 0.6 to 1.2 mg/L (chronic) 3−6 mg/L (acute)	NA
Sediment/uranium	0.23 mg/kg	30,000–120,000 mg/kg	NA	NA
Sediment/radium-226	5 pCi/g[c]	1,700 to 6,900 pCi/g	NA	NA

[a]Concentrations in water and sediments that are greater than the listed exposure levels may indicate a potential unacceptable risk.

[b]Range values are the lowest wildlife no-observed-adverse-effects-level (NOAEL) drinking water standards, 7.00 for mammals (white-tailed deer) and 68.8 for birds (rough-winged swallow) (see Appendix A2).

[c]pCi/g = picocuries per gram.

For the purpose of analysis, a large disposal cell failure (20 to 80 percent of the tailings eroded) was assumed to occur over a short duration (10 hours). Although such a large event would be unlikely, the analysis is useful in projecting potential environmental consequences of a worst-case scenario. The Colorado River was assumed to be at high flood stage during the tailings release. Concentrations of uranium, ammonia as nitrogen, and radium-226, the most prevalent contaminants, were estimated for the failure scenarios.

The following assumptions were made to estimate the concentrations of uranium and ammonia as nitrogen in Colorado River water following a catastrophic tailings release (DOE 2003b):

- The total volume of tailings is 10.5 million tons; 25 percent of the volume is pore water (NRC 1999).
- Volumes of 20 and 80 percent of the tailings eroded into the river at a constant rate over a period of 10 hours (NRC 1999).
- Disposal cell failure occurs during a PMF, and the average river flux over the 10-hour period is 150,000 cfs, or half the 300,000 cfs maximum flux (NRC 1999).
- Concentrations of uranium and ammonia in tailings pore fluids and solid phases are the geometric means of all tailings samples.
- Uranium partitions between solid-phase tailings and river water according to a linear relationship with a distribution ratio of 3.0 mL/g.
- All ammonia is dissolved into the river water (based on its common occurrence in soluble salts at the Moab site).
- Colorado River water mixes with Green River water at a ratio of 1.2:1.0, a 30-year average value determined from river gage stations at Cisco, Utah (Colorado River), and Green River, Utah (Green River) (USGS 2004).
- There is no dispersion of the dissolved phase.

- Colorado River water mixes uniformly with 50 percent of the water in Lake Powell; Lake Powell contains 6.85 trillion gallons (USBR 2004).
- There is no sorption of dissolved contaminants to clean suspended load in the river.

The calculation indicates that the river has 1.0 to 4.0 mg/L of uranium and 21 to 84 mg/L ammonia as nitrogen at the Moab site immediately following the release (Table 4–17). The Green River enters the Colorado River about 50 miles downstream of the Moab site. Water transport time to the Green River confluence is about 15 hours. Mixing with water from the Green River dilutes the uranium concentration to 0.55 to 2.2 mg/L (Table 4–17). Mixing with water in Lake Powell further dilutes the uranium concentration to 0.006 to 0.012 mg/L. Ammonia concentrations decrease to 12 to 48 mg/L and 0.12 to 0.48 mg/L following dilution by the Green River and Lake Powell, respectively (Table 4–17).

Table 4–17. Calculated Concentrations of Dissolved Uranium and Ammonia (as N) in Colorado River Water Following a Catastrophic Failure at the Moab Site

Constituent	Tailings Pore Fluid (mg/L)	Tailings Solid Phase (mg/kg)	Concentration at Moab Site (20% release (mg/L)	Concentration at Moab Site (80% release (mg/L)	Concentration after Green River (20% release) (mg/L)	Concentration after Green River (80% release) (mg/L)	Concentration after Lake Powell (20% release) (mg/L)	Concentration after Lake Powell (80 % release) (mg/L)
Uranium	6.63	81.0	1.0	4.0	0.55	2.2	0.006	0.012
Ammonia-N	1,607	1,654	21	84	12	48	0.12	0.48

Source: DOE 2003b.
mg/L = milligrams per liter.

Sediment released during a catastrophic event would deposit in the river bottom or along banks or become part of the suspended load. Fine-grained portions of the sediment would remain in suspension and rapidly transport downstream. Where the river overflowed its banks, fine-grained sediment would be deposited by settling in standing water. The concentrations of contamination in backwater areas would depend on (1) the proportion of fine-grained tailings to clean suspended load, (2) concentration in the suspended tailings, and (3) the mass deposited over a given area. During periods of low flow, fine-grained sediment would be deposited; during high flow, these deposits would be remobilized and transported farther downstream. The sediment would be dispersed and mixed with clean sediment during transport, causing a continual decrease in contaminant load. Based on detailed studies of deposition of radioactive sediment in the Colorado River Basin, it would be expected that very small amounts of contamination would accumulate in the main river channel (HEW 1963).

The most significant mill-related contaminant in the sediment would be radium-226 because of its low tendency to partition (dissolve) in water and its abundance in the tailings (HEW 1963). The calculated radium concentration is based on the assumption that all the radium-226 is partitioned to (held in) the solid phases. Concentration of uranium in the suspended load was calculated by assuming chemical equilibrium with the dissolved phase. Fifty percent of the tailings sediment is assumed to become suspended load, and the other 50 percent is bedload. Uranium concentration in the suspended load of clean sediment is assumed to be 2,000 mg/L and is based on USGS suspended load data from the Cisco, Utah, gaging and sampling station (DOE 2003b).

Table 4–18 presents the calculated concentrations of uranium and radium-226 in the suspended sediment load. These concentrations represent the maximum values that could result in areas where suspended sediment settles out, such as an overbank area. The uranium concentrations in the Colorado River based on the 20-percent failure scenario (2.2 mg/kg near the Moab site and 1.2 mg/kg below the confluence with the Green River) are relatively low and are near the crustal average of 1.8 mg/kg (Mason and Moore 1982). Radium-226 concentrations are well above the 40 CFR 192 cleanup standards of 5 and 15 pCi/g in all cases. Radium-226 deposited from suspended sediment after a catastrophic failure could be of concern.

Table 4–18. Calculated Concentrations of Uranium and Radium-226 in Suspended Load in the Colorado River Following a Catastrophic Failure at the Moab Site

Constituent	Concentration at the Moab Site (20% release)	Concentration at the Moab Site (80% release)	Concentration Below Green River Confluence (20% release)	Concentration Below Green River Confluence (80% release)
Uranium (mg/kg)	2.2	8.8	1.2	4.8
Radium-226 (pCi/g)	944	3,776	515	2,060

Source: DOE 2003b.
mg/kg = milligrams per kilogram; pCi/g = picocuries per gram.

Table 4–19 compares the maximum exposure levels that would be protective of human and ecological health to the estimated range of concentrations after a catastrophic disposal cell failure.

As shown in the tables, if a house were constructed in a contaminated area and contaminated water was used as the primary source of drinking water, risk above the protective levels would occur under the residential scenario. This impact would be more pronounced near the Moab site and would decrease after the influx of the Green River and mixing occurred in Lake Powell. The highest risks would likely occur from constructing a house in an area contaminated with radium-226. Potential concentrations would be much higher than the protective levels for surface soils.

Concentrations under the camping scenario would not appear to present risk above protection levels, with the possible exception of radium-226 in soils. Under worst-case assumptions, this could exceed protective levels.

The degree of contaminant impact to aquatic receptors would depend upon (1) the type, duration, and areal extent of the failure event, and (2) the mass and concentrations of contaminants released into the Colorado River. Because of uncertainties associated with a contaminant release, and cumulative effects that are not contaminant-related, specific impacts to endangered species are difficult to assess.

Table 4–19. Comparison of Risk-Based Maximum Exposure Levels to Estimated Concentrations Following a Disposal Cell Failure

Medium/ Contaminant	Concentration Range (Lake Powell to Moab)	Maximum Exposure Level Protective of Human Health (Residential Scenario)[a]	Maximum Exposure Level Protective of Human Health (Camping Scenario)[a]	Maximum Exposure Level Protective of Ecological Resources (Aquatic)[a] (mg/L)
Water/uranium (mg/L)	0.006−4.0	0.11	19−36	0.0026−0.455 1.3 (chronic) 2.1 (acute)
Water/ammonia-N (mg/L)	0.12−84	0.21	NA	Approx. 0.6 to 1.2 (chronic) 3−6 (acute)
Sediment/uranium (mg/kg)	1.2−8.8	0.23	30,000–120,000	N/A
Sediment/ radium-226 (pCi/g)	515−3,776	5	1,700−6,900	N/A

[a]Concentrations in water and sediments that are greater than the listed exposure levels may indicate a potential risk.
mg/kg = milligrams per kilogram; mg/L = milligrams per liter; pCi/g = picocuries per gram; N/A = not available.

Assuming catastrophic failure, short-term adverse impacts to aquatic receptors from contaminants would be likely in surface waters and sediments adjacent to the site. These negative impacts would likely decrease as the contaminant concentrations were reduced through dilution and dispersion downstream. Impacts from elevated ammonia at the Moab site downstream to Lake Powell would likely be short term. Ammonia degrades and volatilizes and is not expected to persist in the environment. Although the uranium surface water benchmarks would be exceeded, impacts would more likely occur from elevated concentrations in the sediment. Uranium accumulates in sediments and enters the food chain by adsorption on surfaces of plants and animals and by ingestion of sediments and contaminated food (Driver 1994; Cooley and Klaverkamp 2000; Swanson 1983). Thus, impacts from uranium in the sediments may be longer term because it complexes with sediments where it is likely to be more persistent.

Catastrophic pile failure as a result of an unexpected event could also cause negative impacts to aquatic habitat within areas that are relatively close to the site. Habitat loss could include degradation of backwater nursery areas as a result of elevated concentrations of contaminants and sediment loading. This loss could be extensive in the short term. Once the river dynamics normalized, newly created fish habitat, including backwater areas, could be adversely affected depending upon the duration and concentrations of the contaminant release from the material deposited from the pile.

Catastrophic pile failure would also result in increased turbidity and sediment, which could affect the aquatic and benthic producers. With the loss of primary producers, there would be an effect to the entire food chain.

If mitigated, long-term failure would not likely result in negative impacts to aquatic biota. This type of release, which is possible at all UMTRCA Title I sites, can be mitigated. DOE's newly created (2003) Office of Legacy Management is responsible for monitoring and mitigating this type of release. In addition, all currently available evaluations of the site's geologic and hydrologic conditions suggest that future lateral migration of the river will tend toward the east, away from the site (See Table 2–33, No.10 in the EIS). Further, DOE has incorporated a buried riprap diversion wall into the on-site disposal design to mitigate potential impacts should lateral river migration occur. It has been estimated that this engineering control could easily be enhanced or modified in the future should river migration cause encroachment on the site and the disposal cell.

Assuming catastrophic failure, uranium concentrations in Colorado River water would not likely cause negative impacts to terrestrial receptors from the Moab site downstream to Lake Powell. The potential for negative impacts from elevated uranium concentrations in sediment and shoreline soils is unknown. The variable nature of these substrates influences uranium bioavailability and uptake; thus, no single value or benchmark can be applied (Driver 1994). However, riparian communities would be expected to be lost and dependent species displaced. Habitat loss would be extensive and short term. Recolonization of riparian communities and dependent biota would be expected.

Long-term disposal cell failure would not result in negative impacts to terrestrial biota either through increased contaminant concentrations or habitat loss. Estimated concentrations of uranium after a catastrophic failure would approach the background concentrations currently found in Lake Powell. Ammonia levels might still be elevated in Lake Powell, but considerable volatilization and degradation would be expected as the contamination traveled downstream (this was not considered in the calculations). Much of the radium-226 would be expected to settle out in Lake Powell. Therefore, a major tailings release is not anticipated to significantly increase risks to the human populations located downstream of Lake Powell.

4.1.18 Environmental Justice

Executive Order 12898, *Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations* (59 FR 7629), directs federal agencies to identify and address, as appropriate, disproportionately high and adverse human health or environmental effects of their programs, policies, and activities on minority populations and low-income populations. Minority and low-income populations in the area within 50 miles of the Moab site are described in Section 3.1.20.

The Council on Environmental Quality has issued guidance (CEQ 1997) to federal agencies to assist them with their NEPA procedures so that environmental justice concerns are effectively identified and addressed. In this guidance, the Council encouraged federal agencies to supplement the guidance with their own specific procedures tailored to particular programs or activities of an agency. DOE has prepared the *Draft Guidance on Incorporating Environmental Justice Considerations into the Department of Energy's National Environmental Policy Act Process* (DOE 2000) based on Executive Order 12898 and the Council on Environmental Quality environmental justice guidance.

Among other things, the DOE draft guidance states that even for actions that are at the low end of the scale with respect to the significance of environmental impacts, some consideration (which could be qualitative) is needed to show that DOE considered environmental justice concerns. DOE needs to demonstrate that it considered apparent pathways or uses of resources that are unique to a minority or low-income community before determining that, even in light of these special pathways or practices, there are no disproportionately high and adverse impacts on the minority or low-income population. The DOE draft guidance also defines "minority population" as a populace where either (1) the minority population of the affected area exceeds 50 percent or

(2) the minority population percentage of the affected area is meaningfully greater than the minority population percentage in the general population.

In this draft EIS, DOE applied the environmental justice guidance to determine whether there could be any disproportionately high and adverse human health or environmental impacts on minority or low-income populations surrounding the Moab site as a result of the implementation of the on-site disposal alternative. Environmental justice concerns were analyzed through an assessment of the impacts reported. Although no high and adverse impacts were identified, DOE considered whether minority or low-income populations would be disproportionately affected by the alternatives.

An assessment of the census data found that, within the 50-mile area around the Moab site, less than 1 percent of the population had a household income below $18,244, the poverty level for a family of four.

DOE has identified no high and adverse impacts, and there are no minority or low-income populations who would be disproportionately affected by implementation of the on-site disposal alternative.

4.2 Off-Site Disposal (Klondike Flats Site)

The Klondike Flats site is the closest of the alternative disposal sites to the Moab site (approximately 18 miles to the north). This section discusses the short-term and long-term impacts associated with the first of three off-site disposal alternatives. The impacts are based on the proposed actions described in Section 2.2 and the affected environment described in Section 3.2 of this EIS. This alternative may result in the following impacts:

- Impacts at the Moab site
- Impacts at the Klondike Flats site
- Transportation impacts associated with moving tailings from the Moab site to the Klondike Flats site
- Monitoring and maintenance impacts at the Klondike Flats site

The combined impacts that may result from these activities are then summarized for each assessment area (e.g., Geology and Soils) at the end of each subsection. For many activities, impacts at the Moab site would not differ significantly from those described in Section 4.1. Impacts of characterization and remediation of vicinity properties would be the same as those described in Section 4.1. Transportation impacts would vary, depending upon the transportation mode (truck, rail, or slurry pipeline). Vicinity property materials would be co-transported from the Moab site to the Klondike Flats site. Therefore, impacts associated with transporting vicinity property materials are not addressed separately. Impacts associated with borrow areas are addressed collectively in Section 4.5 and are therefore not addressed in this section.